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THE MECHANISM OF ENZYMATIC OXIDATIONS AND REDUCTIONS

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I. INTRODUCTION

THE investigations of the last two decades have added greatly to our knowledge of the chemical nature of the enzymes of oxidation-reduction and their physiological roles in cellular metabolism. This subject has been reviewed elsewhere by Oppenheimer and Stern (1939), Green (1940), Sumner and Somers (1947), Kalckar (1941), and Goddard (1945), and will be only incidentally dealt with in this article.

This paper is an attempt to present a unified treatment of the mechanism of a diversity of enzymatic oxidation-reductions and the pertinent kinetic relationships. A few basic assumptions are used as the foundation for the treatment:

1. The enzymes of oxidation-reduction are conjugated proteins with a prosthetic group or simple proteins acting with organic coenzymes.
2. Every enzyme of oxidation-reduction has two substrates, an electron donor and an electron acceptor.
3. The enzymes are active partners in the mechanism of the reactions, but the cyclical nature of the reactions returns the enzyme to its original state. That is, they are true catalysts.
4. An enzyme may itself be a substrate for another enzyme.
5. A trimolecular complex is formed between the enzyme, the acceptor, and the donor, in two bimolecular reactions.
6. Electron transfer in univalent steps constitutes the oxidation, and hydrogen transfer occurs through the solvent by ionic association and dissociation.
7. The catalysis occurs within the acceptor-enzyme-donor ternary complex by univalent electron transfer. This results in the formation of free radicals (or semiquinones) of enzyme-donor, enzyme-acceptor, or acceptor-enzyme-donor. We consider it improbable that free radicals in the solvent play an appreciable role in cellular metabolism.
8. The concepts of oxygen activation and chain reactions are not only unnecessary but are impossible, if the high specificity which enzymes show is to be retained.
9. The kinetics of enzymatic reactions can be explained in terms of the rates of formation of the binary complexes and perhaps of the ternary complex.

Many of these assumptions are not original with us, but we do not know of any treatment where they have all been made and where the conclusions have been drawn which follow from these assumptions.

After attempting to justify these assumptions, we shall use them as a basis for a kinetic treatment

of the enzymatic oxidations. Further, the Michaelis-Menton theory which was developed for an enzyme and one substrate will be extended to include the cases of two substrates.

Many of the enzymes of oxidation-reduction have been obtained in essentially pure form (see the citations in the opening paragraph), and all so isolated have been proteins. For example, catalase (Sumner and Dounce, 1937, 1939, 1941) and peroxidase (Theorell, 1943a) are heme proteins containing the same heme as hemoglobin; here the specificity would seem to be determined by the protein. Several are flavoproteins containing as the prosthetic group either riboflavine phosphate or adenine-flavine-dinucleotides. In the case of the heme enzymes, the heme is so firmly attached that, under physiological conditions, it cannot be demonstrated that the enzyme dissociates. In the case of a flavoprotein, such as cytochrome reductase, the dissociation has been measured by Haas and coworkers (1940, 1942), and may be represented as follows:

(1) *enzyme* $\rightleftharpoons$ *protein* + *riboflavine phosphate*

(2) $$\frac{(\textit{riboflavine phosphate})\ (\textit{protein})}{(\textit{enzyme})} = Ke$$

where Ke = dissociation constant, and for this case has the value of 10^{-9}M.

Many of the dehydrogenases are active in the presence of either coenzyme I (cozymase, or diphosphopyridine nucleotide) or II, and others only in the presence of coenzyme II (triphosphopyridine nucleotide). Warburg (1938) has considered that these coenzymes are the prosthetic groups of enzymes which dissociate as follows:

(3) *alcohol dehydrogenase* $\rightleftharpoons$ *specific protein* + *coenzyme I.*

The dissociation constants have been measured by Negelein and Wulff (1937b) for the coenzyme and reduced coenzyme, and were 9.5×10^{-5}M and 3.2×10^{-5}M, respectively.

There is, however, an alternate interpretation in reference to the dehydrogenases. We might consider the specific protein as the enzyme and the coenzyme as the substrate, and, following Dixon and Zerfas (1940), represent the conditions as shown in reaction (4):

(4) *alcohol* + *coenzyme* $\underset{\longleftarrow}{\overset{\textit{enzyme}}{\longrightarrow}}$ *acetaldehyde* + *coenzyme*·H_2

in which we consider the specific protein as an enzyme catalyzing a bimolecular reaction between substrate and coenzyme. The enzyme is not entirely specific for the coenzyme, since the latter may be replaced by an alloxan (Dixon and Zerfas, 1940); so there is good reason to consider the coenzyme as an enzyme substrate and not as a prosthetic group.

One may postulate two substrates for the enzymes of oxidation solely on the theoretical ground that every oxidation requires an equivalent reduction. There is, however, an abundance of experimental evidence for the necessity of two substrates. The enzyme peroxidase does not decompose hydrogen peroxide unless a suitable electron donor is also present. The oxidases which function with molecular oxygen as electron acceptors are inactive except in the presence of a specific electron donor.

The specificity may be complete, that is, when only a single electron acceptor and a single electron donor are known; or several acceptors or donors may be active with a single enzyme. For example, cytochrome oxidase (Keilin and Hartree, 1939a) is an enzyme which is known to react only with one electron acceptor, oxygen, and a single electron donor, the heme protein, cytochrome C:

(5) 4 *ferrocytochrome C* + O_2 + $4H^+$ $\xrightarrow[\textit{oxidase}]{\textit{cytochrome}}$ 4 *ferricytochrome C* + $2H_2O$

Net change: Four electrons donated by four ferrocytochrome C molecules and accepted by an oxygen molecule; four H^+ donated by environment to form $2H_2O$.

A particularly interesting case is that of catalase, which decomposes hydrogen peroxide. Here, a single substrate appears adequate, but we propose that catalase acts on two molecules of hydrogen peroxide simultaneously through the formation of a trimolecular complex of H_2O_2-enzyme-H_2O_2.

The enzymes of oxidation-reduction may actually undergo chemical change during the course of the reaction. For example, the reaction between coenzyme II (triphosphopyridine nucleotide) and cytochrome C or methylene blue is catalyzed by a flavoprotein named cytochrome reductase (Haas et al., 1940, 1942):

(6) *coenzyme*·H_2 + 2 *ferricytochrome C* $\underset{\longleftarrow}{\overset{\textit{flavoprotein}}{\longrightarrow}}$ *coenzyme* + $2H^+$ + 2 *ferrocytochrome C*

Net change: Two electrons donated by ferricytochrome C and accepted by leuco-coenzyme, with the corresponding liberation of two H^+.

If the mechanism of catalysis is examined by adding leuco-coenzyme to the flavoprotein in the absence of cytochrome C, it is found that the flavoprotein is rapidly reduced to its leuco form in a two-electron reduction, probably by way of two univalent steps with a semiquinone (free radical) of the enzyme as an intermediate. If cytochrome C is now added in the absence of cytochrome oxidase, the cytochrome C is reduced and the leuco flavoprotein reoxidized. In this reaction cytochrome C is reduced from ferri- to ferrocytochrome with a single electron change (Hill and Keilin, 1933). Several reactions of this type are known where the enzyme changes its valence state during reaction.

This actual participation of the enzymes in the reaction with a change of valence of the enzyme in a cyclical manner raises the question of whether an enzyme undergoing chemical change in a reaction is a perfect catalyst. That is, are the equilibrium points uninfluenced by the concentration of the enzymes and the valence state of the enzyme? If, for example, we consider the reaction:

(7) $2\ coenzyme \cdot H_2 + O_2 \rightarrow 2\ coenzyme + 2H_2O$

we find that this reaction is catalyzed by an enzyme system of at least three enzymes, flavine enzyme, cytochrome C, and cytochrome oxidase.

(7) a) $2\ coenzyme \cdot H_2 + 2\ flavine\ enzyme \rightarrow 2\ coenzyme + 2\ leucoflavine\ enzyme$

b) $2\ leucoflavine\ enzyme + 4\ ferricytochrome\ C \rightarrow 2\ flavine\ enzyme + ferrocytcchrome\ C + 4H^+$

c) $4\ ferrocytochrome\ C + O_2 + 4H^+ \xrightarrow[oxidase]{cytochrome} 4\ ferricytochrome\ C + 2H_2O$

It is obvious that (7a), (7b), and (7c) are an oversimplification, since none of these reactions will be more than bimolecular. It is also clear that the enzyme is returned to its initial state in a second reaction, so that, in the over-all reaction, if we consider only electron donor and acceptor, the enzyme will not appear in the stoichiometric equation. It is clear, however, that in a closed system with a finite amount of oxygen and coenzyme the equilibrium will not be independent of the concentration of any enzyme undergoing chemical change during the reaction, or of the valence state of the enzyme at the time of its addition.

In practice, we have an unlimited reservoir of oxygen, the whole atmosphere, and because of this the equilibrium is essentially independent of the enzyme concentration or its initial state of oxidation.

In the living cell not only is the oxygen replaced as it is used, but new substrate constantly enters the enzyme system. In fact, except in the study of death, the cellular physiologist is normally concerned with kinetic steady states and not with equilibria.

Some examples of thermodynamically reversible systems catalyzed by enzymes are known. The reaction between the dye, methylene blue, and succinic acid to form fumaric acid and the leuco dye is catalyzed by the widely distributed enzyme, succinic dehydrogenase, as shown in equation (8):

(8) $COOH \cdot CH_2 \cdot CH_2 \cdot COOH + Mb \rightleftharpoons[dehydrogenase]^{succinic} COOH \cdot CH{:}CH \cdot COOH + MbH_2$

Net change: Two electrons donated by succinic acid and accepted by methylene blue accompanied by the dissociation of two hydrogen ions from succinic acid and the association of two hydrogen ions by methylene blue.

Reaction (8) may be written as proceeding in steps:

(8) (a) $succinate \rightleftharpoons^{enzyme} fumarate + 2H^+ + 2e$

(b) $Mb + 2H^+ + 2e \rightleftharpoons MbH_2$

Reaction (8b) is known to be reversible from potentiometric measurements. From the equilibrium constant calculated from thermal data of reaction (8a), and the observed potentials of reaction (8) in the presence of small amounts of dye as compared to the amount of fumarate and succinate, thermodynamic reversibility has been demonstrated (Borsook and Schott, 1931a, b).

One of the best-studied systems from the point

of view of reversibility is the acetaldehyde-alcohol system:

$$(9)\quad CH_3CH_2OH + coenzyme \underset{dehydrogenase}{\overset{alcohol}{\rightleftharpoons}} CH_3CHO + coenzyme \cdot H_2$$

Net change: Two electrons donated by ethanol, two electrons accepted by the coenzyme, two H^+ donated by ethanol, two H^+ accepted by the coenzyme.

This reaction, which was studied by Negelein and Wulff (1937b), may be catalyzed by a crystalline protein enzyme and the equilibrium followed by the difference in light absorption at 3400 Å of the oxidized and reduced coenzyme I (diphosphopyridine nucleotide). The enzyme appears to act as a reversible catalyst, although strict proof of thermodynamic reversibility has not been established.

Studies of the hydrogenase of bacteria by Green and Strickland (1934), as shown in reaction (10),

$$(10)\quad H_2 \underset{}{\overset{hydrogenase}{\rightleftharpoons}} 2H^+ + 2e$$

have shown that the same equilibrium is reached with the enzyme as with platinum black.

The fact that many enzymes actually undergo a valence change during reaction does not justify the generalization made by Goddard (1945) that all enzymes of oxidation-reduction change their valence state during reaction. If certain dehydrogenases are simple proteins (Dixon and Zerfas, 1940), there is no reason to expect that the protein is measurably oxidized or reduced during the reaction. The heme enzyme, peroxidase, appears to remain as ferri-protein (Theorell, 1942b) throughout the catalytic cycle when H_2O_2 is the electron acceptor, though it would appear to undergo reduction within the cell.

Depending on how the system is defined or which partial reaction is studied, a single substance may be an enzyme or a substrate. For example, in reaction (5), cytochrome C is substrate for cytochrome oxidase. In the absence of a substance acting as an electron donor for cytochrome C, the rate of the oxidation may be followed by the rate of change in light absorption at 5500 Å., a wave length at which ferro and ferricytochrome C have different extinction coefficients. We find that, in the oxidation of ascorbic acid, hydroquinone, or cysteine by molecular oxygen in the presence of cytochrome oxidase, cytochrome C functions catalytically (Keilin and Hartree, 1936, 1939a). An examination of the partial reactions will show that every catalyst which itself undergoes a valence change during catalysis must be a substrate in another reaction.

We propose that in enzymatic oxidations a new pathway of reaction between electron acceptor and donor is formed through a trimolecular complex of acceptor-enzyme-donor. The activation energy of electron transfer in univalent steps in the complex may be considerably lower than in the uncatalyzed reaction. We suggest that the rate of reaction in the tricomplex is not rate-limiting but that the rate-determining step is the formation of either the binary complex or the ternary complex, or the rate of decomposition of the ternary complex. One of the following reactions will then determine the over-all rate:

$$\text{donor} + \text{enzyme} \rightleftharpoons \text{enzyme—donor}$$
$$\text{enzyme—donor} + \text{acceptor} \rightleftharpoons \text{acceptor—enzyme—donor}$$
$$\text{acceptor—enzyme—donor} \rightleftharpoons \text{products} + \text{enzyme}.$$

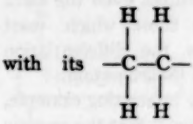
This concept of an intermediate complex of enzyme and a single substrate is old, for it was proposed by Henri (1903). Michaelis and Menton (1913) developed and extended Henri's concept and furnished experimental methods of determining the constants of formation of the intermediate. There is little direct experimental evidence for the existence of such intermediate complexes, for a catalytic complex would be expected to have a short half-life. However, the concept is consistent with the modern concept of chemical kinetics, as developed by Eyring and his associates (see Glasstone, Laidler, and Eyring, 1941), and with considerable kinetic data on enzymatic reactions. Stern (1936) was able to show by spectrophotometric means the existence of an intermediate compound between ethyl hydroperoxide and the enzyme catalase. Where a ternary complex is the intermediate, it should be possible to demonstrate the existence of at least one of the binary complexes in solution. It may be that the order is predetermined; for example, we suspect that oxygen reacts with the oxidases only after the formation of the donor-enzyme complex. The enzyme peroxidase has two substrates, H_2O_2 and an electron donor. Keilin and Mann (1937), Theorell (1942b), and Chance (1943a) have demonstrated a fairly stable complex between H_2O_2 and peroxi-

dase in the absence of an electron donor. Here, one molecule of H_2O_2 unites with the heme of peroxidase, with a shift in the absorption spectrum from a 4-banded spectrum at 6400 Å, 5830 Å, 5480 Å and 4780 Å to a 2-banded spectrum at 5610 Å and 5300 Å (Keilin and Mann, 1937).

The idea of a ternary complex is not new. It was proposed by Mann (1931), and Wolf (1931) suggested that after formation of the complex a series of tautomeric changes in the complex comprise the reaction.

Though there is no observational evidence for the ternary complex, there are voluminous kinetic data best interpreted by this assumption; for example, Chance's (1943a, b) work on H_2O_2, peroxidase, and ascorbic acid; the work of Stotz, Altschul, and Hógness (1938) on O_2, cytochrome oxidase, and cytochrome C; and the work of Haas, Hogness, and co-workers (1940, 1942) on cytochrome, flavoprotein, and coenzyme II. LuValle and Weissberger (1948) have shown that a ternary complex is necessary to explain heavy-metal catalysis of some autoxidation reactions. Michaelis (1929, 1940) and Schubert (1932) have proposed a ternary complex of cysteine, iron, and oxygen, in the iron catalysis of the oxidation of cysteine. Michaelis (1946) has proposed the same ternary complex for enzymatic reactions: "Let us suppose that the enzyme can combine not only with the substrate to be oxidized but also with the oxidizing agent. For example, methylene blue can oxidize succinic acid to fumaric acid in the presence of the enzyme called succinodehydrogenase. Suppose this enzyme can combine with both succinic acid and methylene blue. The specific structure of the enzyme brings about a definite spatial orientation and juxtaposition of fumaric acid and methylene blue. When a molecule of one of these two substances collides with a molecule of the other in a solution, the chance of an electron transfer during the short time of collision is nil; but when these two molecules are held close together in appropriate juxtaposition and orientation with respect to each other, they remain in this spatial arrangement for a long time, during which an electron transfer may occur once in a while. Now, the transfer of a single electron establishes the free radical, and from here on the second step of oxidation takes place readily and spontaneously."

Although a physical juxtaposition of the two substrates may take place, we do not believe that it is a necessary condition for oxidative-reductive processes. It is necessary, however, that the donor and acceptor sites be connected via a mobile electron system, i.e., a resonating system, or a metal atom, or both. One difficulty is how a resonating structure can be set up between enzyme and substrate for a substance, such as succinate,



with its structure. Probably, its structure is markedly changed by combination with the enzyme. Potter and Dubois (1943, 1944) have cited evidence that electron transmission occurs between the succinate and cytochrome C sites of succinate dehydrogenase. It has also been demonstrated by Atkin (1944) that "malonate interferes with the donor enzyme function but not with the enzyme-acceptor function, which were therefore considered to be located at different points on the enzymes."

The Nature of the Bonds between Enzyme and Substrate

The type of bond between the enzyme and the substrate has long been of interest. Warburg (1926) early suggested that oxygen combined with the iron of cytochrome oxidase:

$$(11) \qquad EnFe + O_2 \rightleftharpoons EnFeO_2$$

This idea was based on an analogy with hemoglobin, because the activity of the enzyme was inhibited by CO, HCN, and H_2S, and these substances were known to form compounds with ferro- or ferrihemoglobin. The inhibitory effect of CO was competitive—it depended not upon the partial pressure of CO alone but upon the ratio of O_2/CO. Further, the CO inhibition was reversed by light—as CO-hemoglobin is dissociated by light. All of these reactions constitute strong but not convincing evidence.

Peroxidase, catalase, cytochrome oxidase, and the cytochromes are all heme proteins, and in this they are analogous to hemoglobin. On the other hand, each of these heme enzymes differs from all the others and from hemoglobin in its physiological function. Hemoglobin is an oxygen-carrier, whereas the others are enzymes. In hemoglobin, the oxygen is carried by covalent bonding to the iron atom of the heme. The evidence that the heme enzymes bond their respective substrates to

the iron is inconclusive. In fact, there are very few direct data pertaining to the bonds between enzyme and substrate. But in the case of the heme enzymes there are some data upon the valence state of the iron atoms within the heme. Theorell (1942b) has suggested that the groups bound to the fifth and sometimes even the sixth places of coordination are those which most strongly contribute towards the differentiation in the mode of functioning of the iron atom.

Peroxidase is a particularly interesting example, for Theorell (1943a, b) has shown that the enzyme is a crystalline protein having a molecular weight of 44,100 and containing one heme and one iron atom per molecule. Theorell's magnetic studies (1942b) indicate that the iron is bound ionically with five odd electrons. The addition of H_2O_2 in the absence of an oxidizable substrate causes a shift in the absorption spectrum, and at low concentrations of H_2O_2 a molecular complex of one H_2O_2 per enzyme molecule is rapidly formed. The velocity of formation has been determined by Chance (1943a). The bimolecular reaction constant, k_1, is 1.2×10^7 liter mole^{-1} second^{-1}, and the monomolecular back reaction constant, k_2, is 0.2 second^{-1} or less, where

$$(12) \qquad En + H_2O_2 \underset{k_2}{\overset{k_1}{\rightleftharpoons}} EnH_2O_2$$

The equilibrium constant of dissociation of the complex was estimated, since

$$(13) \qquad K_m = \frac{k_1}{k_2} = 2 \times 10^{-3}$$

indicating a very tight union of peroxidase and hydrogen peroxide.

The magnetometric studies of Theorell (1942b) indicate that the iron in the peroxidase-H_2O_2 compound is ionic and that it forms a stable compound with cyanide, one molecule of cyanide reacting per enzyme molecule. Theorell and Paul (1944) have shown that the groups bound in the fifth and sixth coordination places of iron determine its activity in peroxidases.

The nature of the trimolecular complex between H_2O_2, peroxidase, and acceptor is not known, but it *must have a very short half-life*, as k_3 of equation

$$(14) \quad AH_2 + \textit{peroxidase } H_2O_2 \xrightarrow{k_3} 2H_2O + \textit{peroxidase} + A$$

is 3.0×10^5 liter mole^{-1} second^{-1} when leuco malachite green is the electron donor and 1.8×10^5 liter mole^{-1} second^{-1} when l-ascorbic acid is the electron donor.

Catalase has been isolated as a crystalline heme protein by Sumner and Dounce (1937, 1939), and shown to have a molecular weight of about 225,000 by Sumner and Gralen (1938). It probably contains three hemes per molecule, and a fourth iron atom not linked in the heme. Magnetometric studies of Theorell and Agner (1943) indicate that all of the iron is ionically bound with five odd electrons; and magnetometric titrations with HCN show that saturation with HCN occurs when three Fe atoms combine with HCN. Catalase forms a complex with ethyl hydrogen peroxide, accompanied by a shift in the absorption spectrum (Stern, 1936). The compound with H_2O_2 is of such short life that its presence has never been demonstrated; however, catalase forms in nitrogen a fairly stable compound with sodium azide and H_2O_2. Azide is known as a powerful inhibitor of catalase (Keilin and Hartree, 1938b, 1945a). It may be seen that azide does not prevent the formation of a complex with H_2O_2, but it may prevent the formation of the catalytic ternary compl From Theorell and Agner's (1943) magnetic studies, it appears probable that in azide-catalase H_2O_2, the iron is bound covalently.

Cytochrome functions by alternate oxidation and reduction from the ferri- to the ferro-form, but under physiological conditions it does not form compounds with NaCN, CO, NaF, H_2O_2, O_2, all of which form compounds with either ferro- or ferrihemoglobin. The iron atom appears to be bound by six covalent bonds (Theorell, 1943b), four bonds to the nitrogen atoms of the pyrrole rings and two to the imidazole rings of the histidine of the protein. The magnetic susceptibility indicates but one odd electron. Although no coordination places are thus available for union with O_2 or other substances, cytochrome does form complexes with its oxidase and with cytochrome reductase, so that electrons may be transferred from one to the other, with the dissociation of hydrogen ion to the medium.

As cytochrome C undergoes only a univalent oxidation-reduction, both cytochrome oxidase and cytochrome reductase must be capable of existence as enzyme semiquinones. Haas (1937) has given definite experimental evidence for the semiquinone of the reductase.

The nature of the bonding between dehydro-

genase and the substrate is of real intreset, but little concrete information is available. In several cases (Barron and Singer, 1945) the enzyme is active as a sulfhydryl protein, and is inactive if the SH group is oxidized or substituted. The specificity is usually very high, and compounds of closely related structure often give competitive inhibition, for example, succinic dehydrogenase is inhibited by malonic acid: $HOOC \cdot CH_2 \cdot COOH$. The inhibition depends upon the ratio of malonic to succinic acid, and not upon the concentration of malonic acid alone (Quastel and Whetham, 1924). Potter and DuBois (1943) have studied the inhibition, using succinic acid at M/15, M/20, and M/30 and malonic acid at M/300, M/100, and M/3000; in all, nine combinations were used, and from their results the following calculations may be made:

If malonate and succinate combine with the same enzyme, at any instant the following relations may be written:

(16) (a) $En + S \rightleftharpoons EnS$

(b) $$\frac{[EnS]}{[En][S]} = K_s$$

(c) $En + M \rightleftharpoons EnM$

(d) $$\frac{[EnS]}{[En][M]} = K_m$$

and dividing (b) by (d) gives (e)

(e) $$\frac{[EnS]}{[EnM]}\frac{[M]}{[S]} = \frac{K_m}{K_s} = K$$

where En = enzyme; S = succinate; M = malonate.

If we represent as 1.0 the maximum velocity of the oxidation with a given enzyme preparation, and the residual velocity at any given ratio of succinate and malonate as n, then the inhibited respiration is $1\text{-}n$. Under these conditions,

(17) $n \propto [EnS]$ and $1 - n \propto [EnM]$

and

(18) $$\frac{n}{1-n} \cdot \left[\frac{M}{S}\right] = K$$

We have calculated K from the data of Potter and Dubois, and in eight out of nine experiments it lay between 0.017 and 0.024, with an average value of 0.0196. In other words, when the ratio of malonate to succinate is 0.02, the activity of the enzyme is inhibited 50 per cent.

Potter and DuBois have postulated that the succinate combines with an —SH group of the enzyme and with two peptide bonds, as is diagrammed in their figure 1, reproduced here. They have illustrated the oxidation of the substrate on the enzyme as occurring in two steps, and the intermediate stage, as shown in No. III of their figure, is an enzyme-semiquinone.

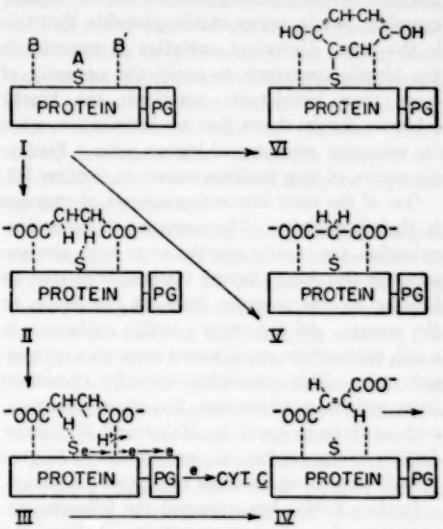


FIG. 1. SCHEMATIC REPRESENTATION OF THE STRUCTURE OF SUCCINIC DEHYDROGENASE ON THE BASIS OF MUTUALLY EXCLUSIVE INHIBITOR REACTIONS

The protein is succinic dehydrogenase, and PG represents its hypothetical prosthetic group.

I = enzyme showing the succinic acid activating center. A is a sulfhydryl amino acid, e.g., cysteine, in a peptide chain; B and B′ are carbonyl affinity points, e.g., —NH— groups of adjacent peptide linkages, capable of forming hydrogen bonds with the carbonyl oxygens.

II = enzyme-succinic acid complex in first stage of succinic acid oxidation.

III = enzyme-succinic acid complex in a possible intermediate stage of succinic acid oxidation.

IV = enzyme-fumaric acid complex resulting from the oxidation of succinic acid.

V = enzyme-malonic acid complex. Only the carbonyl affinity points are involved. Inhibition is reversible. Enzyme-sulfhydryl shielded by malonate and thereby protected against sulfhydryl reagents.

VI = enzyme-quinol complex, as an example of inhibition by a sulfhydryl reagent (quinone). Analogous complexes formed with other quinonoid compounds, thiol reagents, thiols, heavy metals, arsenite, and selenite.

(Potter and Dubois, 1943.)

The evidence for oxidation through univalent steps has been well reviewed by Michaelis and Schubert (1938); and we shall, therefore, not repeat the evidence here. There is little direct evidence for semiquinone formation in the binary complex of substrate-enzyme or in the ternary complex, but it seems highly probable that this is the case. Univalent oxidation is essential in the kinetic treatment to avoid the necessity of more than bimolecular reactions; the kinetic evidence clearly shows that no justification exists for assuming reactions of higher order. Further discussion of this problem occurs in Section III.

One of the most interesting aspects of enzymes is their specificity. The enzymes of oxidation-reduction are usually specific as to both electron acceptor and donor, though the specificity may be broader for the acceptor than for the donor, or the reverse. Of the many possible oxidations in a cell, only certain specific ones occur at a measurable rate. This specificity virtually eliminates from serious consideration the chain reactions, such as those proposed by Haber and Willstätter (1931), Weiss (1946a, b), and Moelwyn-Hughes (1937), as well as concepts of oxygen activation.

Pauling (1946) has proposed the following explanation for enzyme specificity: "From the standpoint of molecular structure and the quantum-mechanical theory of chemical reaction, the only reasonable picture of the catalytic activity of an enzyme is that which involves an active region of the surface of the enzyme which is closely complementary in structure not to the substrate molecule itself, in its normal configuration, but rather to the substrate molecule in a strained configuration, corresponding to the 'activated complex' for the reaction catalyzed by the enzyme; the substrate molecule is attracted to the enzyme, and caused by the forces of attraction to assume the strained state which favors the chemical reaction—that is, the activation energy of the reaction is decreased by the enzyme to such an extent as to cause the reaction to proceed at an appreciably greater rate than it would in the absence of the enzyme. . . . If the enzyme were completely complementary in structure to the substrate, then no other molecule would be expected to compete successfully with the substrate combining with the enzyme, which in this respect would be similar in behavior to antibodies; but an enzyme complementary to a strained substrate molecule would attract more strongly to itself a molecule resembling the strained substrate molecule than it would the substrate molecule." In the same articles Pauling cites some examples.

Beadle (1945) has shown that in the absence of genes in certain cases no enzymatic reaction occurs. Emerson (1945) has suggested that the genes form the enzyme molecules by using their own surfaces as templates for the enzyme molecule, thus creating active centers on the enzyme surface. This implies that the active sites on enzymes are sensitive to the interatomic spacing within the enzyme molecule, just as active sites on surface catalysts are sensitive to interatomic spacing. The concept that the interatomic spacing determines the activity of the catalyst was suggested by Langmuir (1921), given a quantum-mechanical explanation by Sherman and Eyring (1932), and verified experimentally by Beeck, Smith, and Wheeler (1940). This does not imply that the enzyme molecule absorbs molecules over its entire surface. It only implies that on the enzyme surface there exist specific sites at which "activated complexes" between enzyme and substrate may form. Oxidation-reduction enzymes are so shaped that chemical bonds are formed which facilitate the exchange of electrons.

II. ACTIVATION ENERGY AND COLLISION NUMBERS

A. Symbols

κ = Boltzmann's constant
h = Planck's constant
T = Absolute temperature
R = Gas constant = 8.315×10^7 ergs deg.$^{-1}$, 1.98 cal. deg.$^{-1}$
e = Base of natural logarithms
ΔF^* = Free energy of activation for formation of the "activated complex"
ΔH^* = Total energy of activation for formation of the "activated complex"
ΔS^* = Entropy of activation for formation of the "activated complex"
E_s = Experimental energy of activation in solution in kcal. mole^{-1}
Z = Collision frequency per enzyme molecule
Z_s = Collision frequency of enzyme and substrate molecules
A = Activated collision frequency per enzyme molecule
$\sigma_m = \frac{\sigma_s + \sigma_s}{2}$
σ_s = Diameter of enzyme molecule in ångströms

σ_s = Diameter of substrate molecule in ångströms

n_e = Concentration of enzyme in molecules per milliliter

n_s = Concentration of substrate in molecules per milliliter

M_e = Molecular weight of the enzyme molecule

M_s = Molecular weight of the substrate molecule

B. Activation Energy

Biological processes must be completed in a finite amount of time. In general, it appears reasonable to state that processes on the main pathway of energetic metabolism should proceed to half-completion in a fraction of a second, though enzymatic processes of digestion, syntheses of storage products, and some processes involved in growth and differentiation, may have half-lives of hours or even days. The rate constant of the reaction and, therefore its half-life, is determined by the free energy of activation. The upper limit placed upon the free energy of activation in enzymatic reactions may be calculated from the "transition-state" theory (Glasstone, Laidler, and Eyring, 1941). In this theory, the rate constant for any reaction is given by:

$$k = \frac{\kappa T}{h} e^{-\Delta F^*/RT} = \frac{\kappa T}{h} e^{-\Delta H^*/RT} e^{\Delta S^*/R} \quad (1)$$

In terms of the experimental activation energy of a reaction taking place in homogeneous solution, equation (1) becomes

$$k = \frac{e\kappa T}{h} e^{-E_e/RT} e^{\Delta S^*/R} \quad (2)$$

In Fig. 2, values of log k calculated by equation (1) are plotted against ΔF^*. Corresponding values of the half-life for a monomolecular reaction of rate constant, k, are given on the right-hand ordinate. If it is assumed that the entropy of activation is zero, values of k can also be calculated from the experimental values of the activation energy; in such cases, $\Delta F^* = E_e - RT$. Values of E_e are given on the upper abscissa; the experimental activation energies for several enzymatic reactions are also indicated (Sizer, 1943). As virtually all bimolecular reactions are much slower than monomolecular reactions, it appears reasonable to limit the free energy of activation for enzymic reactions to values of less than twenty-five kcal. mole^{-1}. The heavy lines of Fig. 2 mark the area of biological interest.

It is probable that enzymic reactions with experimental energies of activation of the order of 5 kcal. mole^{-1} or less are diffusion-limited reactions, i.e., every collision of a substrate molecule with an active center of the enzyme leads to reaction. It may be that some of the enzyme molecules are so shaped that colliding molecules tend to move toward the active centers, so that virtually every collision will lead to reaction. Debye (1942) has stated that activation energies of 4 to 5 kcal. mole^{-1} or less may easily be explained by diffusion processes.

It would be interesting to compare the activation energies of uncatalyzed reactions with the activation energies of enzyme-catalyzed reactions. The activation energy of the uncatalyzed reaction is usually so high that the reaction does not proceed with a measurable velocity at neutral pH and at physiological temperatures. At high temperatures, the reactants are often unstable, or the products of the reaction markedly different.

Two of the simplest chemical reactions known for which enzymes have been isolated are the dehydration of carbonic acid and the reduction of hydrogen peroxide. For example, the E_e of the uncatalyzed reaction

$$H_2CO_3 \rightleftharpoons CO_2 + H_2O \quad (3)$$

is 20.45 kcal. mole^{-1}. The E_e of the reaction catalyzed by carbonic anhydrase is given as from 8.7 to 11.7 kcal. mole^{-1} (Brinkman, Margaria, and Roughton, 1933). Assuming that the higher value is correct, and ignoring any entropy factors that may be involved, this results in an increase in rate of a millionfold, as is shown in Fig. 2. The E_e for the uncatalyzed decomposition of H_2O_2 is 18.0 kcal. mole^{-1}, while for the enzymic decomposition by catalase it is 6.4 kcal. mole^{-1} (Moelwyn-Hughes, 1933a), and for decomposition in the presence of colloidal platinum, it is 11.7 kcal. mole^{-1}. Again ignoring entropy factors, such a decrease in activation energy means that the enzymic reaction is 10^8 times faster than the uncatalyzed reaction, and that catalase is more than 5600 times as efficient a catalyst as platinum black. The rates are calculated from Fig. 2.

C. Collision Numbers

In equation (2), the factor $e\left(\frac{\kappa T}{h}\right)e^{\Delta S^*/R}$ corre-

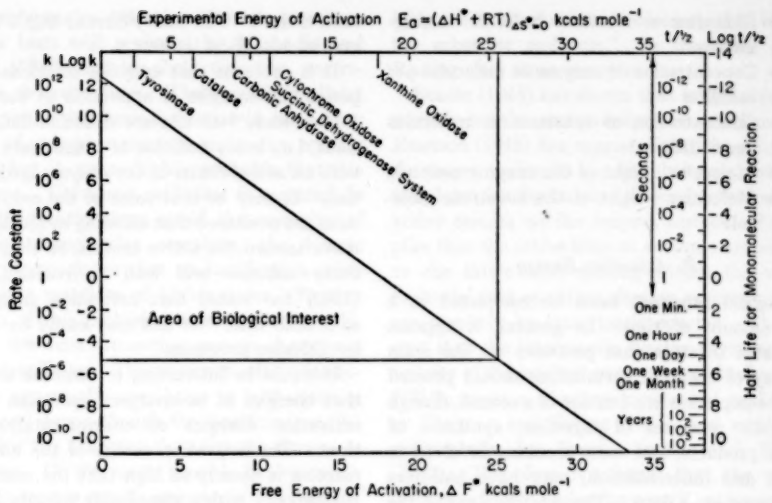


FIG. 2. CHANGE IN RATE CONSTANT WITH CHANGE IN THE FREE ENERGY OF ACTIVATION

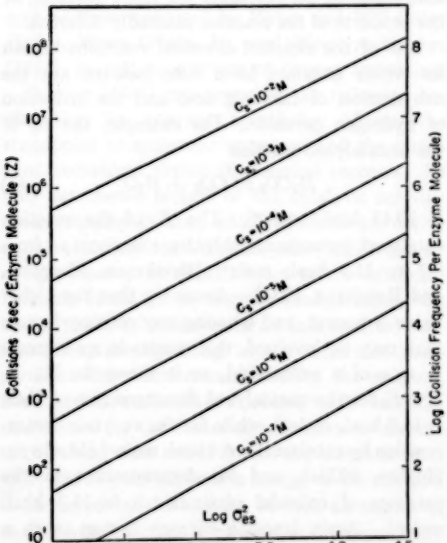


FIG. 3. CHANGE IN COLLISION FREQUENCY PER ENZYME MOLECULE WITH CHANGE IN THE DIAMETER OF THE LATTER FOR GIVEN SUBSTRATE CONCENTRATIONS

sponds to the PZ factor of the collision theory of reaction rates (Moelwyn-Hughes, 1933a). As our knowledge of the entropy change, ΔS^*, is rather meager, we shall use the kinetic collision theory in the following discussion of collision frequency. We are interested in the frequency with which one enzyme molecule undergoes collision with the substrate molecules and in the factors that affect this collision frequency. The collision frequency per enzyme molecule is given by:

$$Z = \frac{eZs}{n_e} = \sigma_{es}^2 n_s \sqrt{8\pi RT\left[\frac{1}{M_s}+\frac{1}{M_e}\right]} \quad (4)$$

The collision equation has been derived for collisions in gases. Although there is some question as to the applicability of this equation to solutions (Debye, 1942; Moelwyn-Hughes, 1933a), we shall use it here on the assumption that it yields correct values. Assuming that the molecular weight of the substrate is in the neighborhood of 100 and that the molecular weight of the enzyme lies between 10^4 and 10^6, values of log Z are plotted against log σ_{es}^2 for several values of the substrate concentration in Fig. 3. The collision frequency per enzyme molecule increases linearly with σ_{es}^2 and with the concentration of the substrate.

In Fig. 4, the logarithm of the Boltzmann factor, $e^{-E_c/RT}$, is plotted against E_c. This gives the fraction of the molecules with activation energy, E_c, for a given value of E_c. If an activated collision is defined as a collision in which there is sufficient activation energy for the reaction to take place, the equation,

$$A = Ze^{-E_e/RT} \quad (5)$$

gives the activated collision frequency per enzyme molecule, A. In Fig. 5, the activated collision frequency per enzyme molecule is plotted against the activation energy for several values of the collision frequency. From Fig. 5, it is easily seen that an activation energy of 5.1 kcal. mole^{-1} means that only 1 in 10^4 collisions will have sufficient energy for a reaction to result, provided all the other necessary conditions are fulfilled. Similarly, an activation energy of 11.3 kcal. mole^{-1} means that only 1 in 100 million collisions may result in reaction. In Fig. 6, the activated collision frequency per enzyme molecule is plotted against log σ_{ss} for given values of the substrate concentration and of the activation energy. It is immediately observed that a substrate concentration of 10^{-3}M and an activation energy of one kcal. mole^{-1} gives a greater activated collision frequency than a substrate concentration of 10^{-2}M and an activation energy of 10 kcal. mole^{-1}.

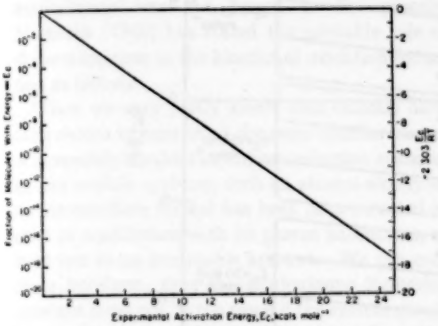


FIG. 4. FRACTION OF MOLECULES WITH ACTIVATION ENERGY, E_e

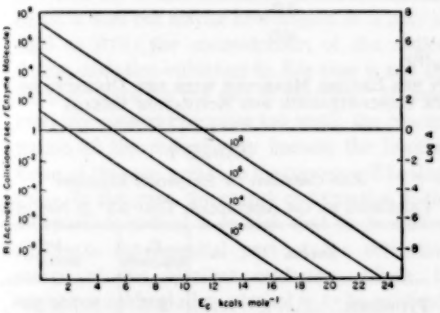


FIG. 5. CHANGE IN ACTIVATED COLLISION FREQUENCY PER ENZYME MOLECULE WITH CHANGE IN ACTIVATION ENERGY FOR GIVEN VALUES OF THE COLLISION FREQUENCY

All of the foregoing calculations have been made, ignoring completely the entropy of activation. If we assume that every collision with activation energy E_e and activation entropy ΔS^* leads to reaction, Fig. 7 gives the reaction frequency per enzyme molecule plotted against the entropy of activation for given values of the activated collision frequency per enzyme molecule. A small change in the entropy of activation can alter the reaction frequency per enzyme molecule (reaction rate) considerably; thus, an increase of 10 kcal. mole^{-1} degree^{-1} in the entropy of activation will increase the reaction rate over a hundredfold.

If we assume that ΔS^* is zero, approximate values of k can be calculated from the values of E_e given by Sizer (1943), using Fig. 2. These calculations are summarized in Table 1. Catalase has a rate constant of 2.4×10^8 liters mole^{-1} second^{-1}. Haldane (1931) has calculated that the minimum rate constant for catalase would be 0.76×10^7 liters mole^{-1} second^{-1}. Since the molecular weight of catalase is given by Sumner and Gralen (1938) as 248,000 and the partial specific volume as 0.73 ml. per gram, the calculated radius, assuming a spherical molecule, is 41.6 Å, giving a total collision frequency of 1.3×10^{10} per enzyme molecule per second, or an activated collision frequency of 2.9×10^5; whereas the rate constant demands 2.4×10^5 reactions per second. Even though catalase contains 3 hemes, it seems highly improbable that every collision will lead to reaction; therefore, either the entropy of activation is positive or the frequency of collision cannot be safely calculated by the gas equation.

III. SEMIQUINONES AND REACTION KINETICS

Michaelis and Schubert (1938) have developed the complete semiquinone theory for reactions in equilibrium, and have suggested that the semiquinone constant must not be too small if the reaction is to be reversible. Weiss (1946a, b) has stressed the role of dimerization and dismutation reactions in free radical mechanisms. Recently, LuValle and Weissberger (1948) have systematically applied the semiquinone theory of Michaelis to autoxidation kinetics in aqueous solution. They found that much of the autoxidation data could be systematized and classified upon the basis of the rate laws derived from the postulated mechanisms. All of the mechanisms are derived from

one basic group of equations by varying the relative values of the specific reaction rate constants. In the non-catalytic and autocatalytic reactions, the semiquinone is found to exist free in the solution. In catalyzed reactions, the data are best explained by formation of ternary complexes between catalyst, donor substrate, and acceptor substrate, oxygen. In inhibited reactions, the data are best explained by formation of complexes between inhibitor and semiquinone. Rather than derive these equations again, we refer the interested readers to the original papers.

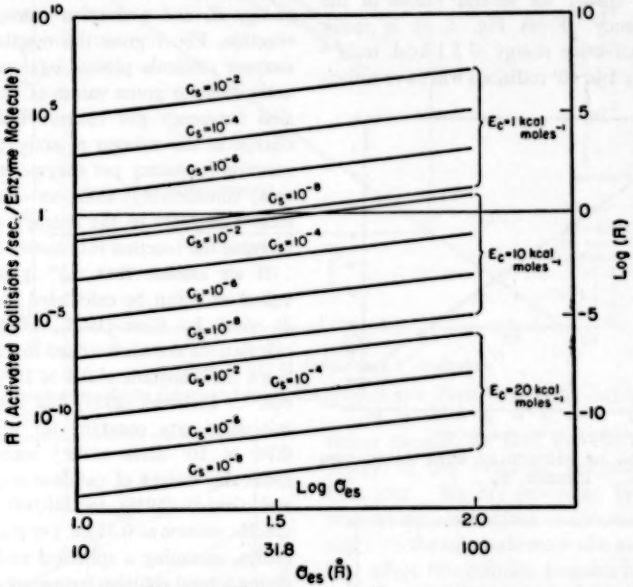


FIG. 6. CHANGE IN ACTIVATED COLLISION FREQUENCY PER ENZYME MOLECULE WITH THE DIAMETER OF THE LATTER FOR GIVEN VALUES OF SUBSTRATE CONCENTRATION AND ACTIVATION ENERGY

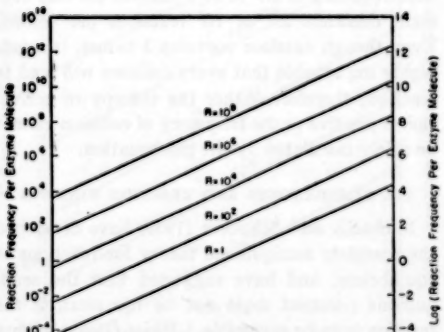


FIG. 7. EFFECT OF ENTROPY OF ACTIVATION ON THE REACTION FREQUENCY PER ENZYME MOLECULE

TABLE 1

Rate Constants for Enzymatic Reactions

Calculated on the Assumption That ΔS^{*} Is Negligible

ENZYME	E_a kcal/mole	k^{++} second^{-1}
Tyrosinase	2.7	9.7×10^{10}
Catalase	6.4	2.4×10^{8}
Carbonic anhydrase	8.9	4.5×10^{6}
Cytochrome oxidase	11.2	1.0×10^{5}
Xanthine oxidase	18	1.7

^{++}k is here a pseudomonomolecular rate constant.

We do not believe it probable that the formation of unbound semiquinones or free radicals plays an important role in cellular metabolism, but prefer to visualize the semiquinones as formed within the enzyme complex and remaining within the complex throughout their lifetime. By such a mechanism we retain the concept of enzyme specificity and avoid the initiation of chain reactions or non-specific oxidations. Any appreciable

formation of unbound free radicals should lead to the destruction of life itself.

Michaelis and Smythe (1938) have suggested that biological oxidation-reductions proceed through semiquinone formation. Haas, Harrer, and Hogness (1942) have found evidence for the presence of alloxazine free radicals in experimental work with cytochrome reductase. However, they were not able to demonstrate that the alloxazine semiquinone was not bound to the protein. Michaelis (1940) has stated the probable role of the semiquinone in the kinetics of oxidation-reduction as follows:

"Now we may justly assert that radicals have been shown to exist in all the more familiar classes of reversible bivalent oxidation-reduction systems. In irreversible systems, such as alcohol-aldehyde, no intermediate radical has been demonstrated to exist in equilibrium with its parent substances, at least not to an analyzable amount. We can conclude herefrom, that the semiquinone formation constant must not be too small if the system should behave as a reversible one. Any bivalent oxidation must and can proceed only in univalent steps. Provided the radical formation constant is not too small, it does not matter how large it is; it may be 1000 or 0.01; the concentration of the radical during oxidation-reduction in this case is not the limiting factor for the rate of reaction. If, however, this constant becomes too small, the concentration of the radical may become the limiting factor of the rate, and then the process will be sluggish. In this case, the energy of formation of the intermediate radical is so high that its formation represents the essential part of the activation energy of the bivalent oxidation. When, in neutral or acid solution, alcohol is to be oxidized, the potential range of the oxidizing agent must be positive enough to form the radical; and if aldehyde is to be reduced, the potential range of the reducing agent must be negative enough to form the radical. The difference of the potential range of that oxidizing agent just strong enough to oxidize alcohol at a measurable speed, and that of the reducing agent just strong enough to reduce aldehyde with a measurable speed, is the difference between what Conant and Fieser have called the apparent oxidation potential of alcohol, and the apparent reduction potential of aldehyde. In a reversible system, both coincide; in other words, there is no over-voltage either in reduction or in oxidation. The role of a catalyst, or a respiratory enzyme, is to diminish the energy necessary to form the intermediate radical. For this purpose, the catalyst should be able to form a compound with the substrate in which the equilibrium between the oxidized form of the substrate, the reduced form, and the intermediate radical, is more in favor of the radical than in the uncombined substrate itself. Although this idea still needs further experimental support, it has in any case the advantage of reducing a problem of kinetics to one of thermodynamics."

IV. MECHANISM OF REACTIONS AND RATE LAWS

A. Symbols

E	= enzyme; includes prosthetic group other than coenzyme.
$E_{\cdot}^{-}$, $E_{\cdot}^{+}$	= enzyme semiquinones.
Co	= coenzyme.
CoH	= coenzyme semiquinone.
CoH_2	= leuco coenzyme.
RH_2	= leuco donor which may undergo a bivalent oxidation.
RH_2^+ RH	= semiquinone of leuco donor.
R	= oxidized donor.
RH	= donor which may undergo a univalent oxidation.
R	= oxidized donor which may undergo a univalent reduction.
A	= acceptor which may undergo a bivalent reduction.
A^-, AH	= acceptor semiquinone.
AH_2	= leuco acceptor.
O_2	= oxygen acting as an acceptor.
O_2^-	= perhydroxyl ion.
HO_2^-	= hydroperoxide ion.
HO	= hydroxyl radical.

B. General Concepts—Basic Assumptions

This section consists of a simplified treatment of the mechanisms of oxidation-reduction, and many possible mechanisms will be omitted. The mechanisms derived for the several classes of oxidation-reduction enzymes are based upon the two following basic assumptions:

(1) *All reactions proceed through a series of univalent electron exchanges.*

(2) *A ternary complex of donor, enzyme, and acceptor must be formed for the reaction to proceed to completion.*

Upon these two assumptions it is possible to construct a rational picture of enzymatic action in

biological oxidations which is fundamentally the same for all classes of oxidative-reductive enzymes.

If we combine the ideas of Pauling (1946) and Michaelis (1940, 1946) with the ideas we have developed, an oxidative-reductive enzyme may be pictured as a protein molecule which has several active centers on the surface. One of these sites is specific for the prosthetic group (when such a group is required). Of the remaining active sites, part are specific for the donor substrate (electron donor) and part for the acceptor substrate (electron acceptor). The specificity varies with the enzyme and is ascribed to its shape and to the interatomic distances on the surface of the sites, especially to the interatomic distances between those atoms which form chemical bonds (Pauling, 1940) with the substrate. These bonds facilitate the transfer of electrons between the donor and the acceptor. The donor and acceptor sites must be connected by a mobile electron system. In some cases the prosthetic group may serve as one of the specific sites. The number of active sites may vary upwards from two (one for each substrate).

The enzyme-substrate bond is probably a bond between two free radicals formed in a univalent oxidation-reduction when the substrate is initially attached to its site. The bond may be stabilized by resonance, or it may be a hetero-dimer bond formed by the two free radicals. Where sulfhydryl groups are present in the substrate site, the dimer bond is probably to the sulfur atom. Discussion of the exact nature of the mobile electron system connecting the active sites on the protein must await more information about the structure of the sites and the protein surface.

The prosthetic group of an enzyme may actually undergo an oxidation-reduction during the enzymatic cycle, it may serve merely as a mobile electron system which transmits electrons from one active site to another active site, or it may serve to stabilize the protein in certain intermediate states. The transition group elements, e.g., Fe, Cu, Zn, all have low-lying vacant outer orbitals which may be utilized to stabilize some of the transitory structures by formation of bonds similar to those found in ionic complexes, e.g., $Fe(CN)_6^{=}$, $CuCl_2^{-}$, and $Cu(NH_3)_4^{++}$. Calvin and Wilson (1945) have suggested a similar stabilization of chelate structures. For the dehydrogenases, however, the coenzyme can be thought of as playing the role of an electron acceptor or donor, according to the reaction in which it is involved. This electron acceptor or donor undergoes bivalent oxidation-reductions.

Inhibition of enzymatic reactions is of considerable theoretical as well as experimental interest. Enzymatic reactions may be inhibited by any one of several means: (a) by the removal of a substrate by a competing reaction; (b) by denaturation or precipitation of the enzyme by high temperatures, ultraviolet light, and x-rays (Northrop, 1938), by denaturing and precipitating agents and the presence of high or low pH; (c) by the action of certain non-specific surface-active agents, such as the urethanes and octyl alcohol—the mode of action of these agents is not very clear, but presumably they block the active sites or change the surface configuration; (d) by agents which react with certain specific groupings, such as the reaction of enzyme sulfhydryl groups with iodoacetic acid, arsenoxides, and phenyl mercurial salts; (e) by substances of chemical configuration similar to the natural substrate, such as the malonic acid inhibition of succinic dehydrogenase (Roblin, 1946, has reviewed the literature of this type of inhibition); (f) by substances which act at the site of normal attachment of the prosthetic groups; or (g) by compounds which form active complexes with the metal atoms of the prosthetic groups, such as CO, HCN, HN_3, NH_2OH, etc. The new complex may block out the acceptor or donor from the complex, or the inhibitor may effectively prevent electron exchange between the two substrates through the enzyme by blocking of the outer orbitals of the transition group elements and thus prevent the use of these orbitals in the stabilization of intermediate enzyme structures. Thus, the azide inhibition of catalase may be due to the prevention of the formation of the ternary complex, $H_2O_2 \cdot \text{catalase} \cdot H_2O_2$, by the formation of the relatively stable $HN_3 \cdot \text{catalase} \cdot H_2O_2$, or to the formation of a molecular configuration which prevents electron transfer.

Further investigation of inhibition should give information as to the structure of the enzyme. Investigation of inhibition by (a), (d), (e), (f), and (g) above should give information as to the shape, nature, and perhaps composition of the active sites.

For purposes of discussion we may assume that the basic reactions are fairly simple. The enzyme and either the donor or acceptor form a binary complex, which then reacts with the other substrate (acceptor or donor) to form a ternary com-

plex. Prior to formation of the ternary complex, the binary complex may undergo an internal univalent oxidation-reduction, forming a binary radical consisting of a complex of enzyme semiquinone and substrate semiquinone. The ternary complex undergoes a series of univalent electron exchanges, followed by dissociation into free enzyme and the products of the reaction. We shall assume that only electron exchange takes place within the complex and that the transfer of hydrogen ion takes place via the solvent through ionization processes. Actually, the hydrogen ion dissociated is probably rarely the hydrogen ion associated. A transfer of hydrogen atoms probably rarely occurs, since it cannot occur as free atomic hydrogen, which would literally burn up the cell, because it would react with its first collision partner. The probability of transferring a proton plus an electron simultaneously without release of atomic hydrogen is much less than electron transfer preceded or followed by hydrogen-ion dissociation. The ionization processes may precede complex formation, occur during the life of the complex, or follow complex dissociation. Hogness (1942) and Barron (1942) have expressed similar views regarding hydrogen transport.

In the following sections the mechanisms of reaction for the several classes of oxidative-reductive enzymes are developed in detail and the corresponding rate laws derived from the mechanisms. In the derivation of the rate laws a simplified mechanism is used, in which reactions denoting internal electron exchange and external hydrogen-ion exchange are deleted, since the rates of electron and of hydrogen-ion exchange are not rate-limiting but only introduce equilibrium constants. The effect of ionization reactions upon the concentrations of the reactive species is also not included in the derivations, since specific experimental data for each reaction should first be available, so that the step in which ionization occurs may be located. The rate-limiting reactions are those in which complexes are formed or destroyed.

When the concentration of the donor is such that the free time (time interval during which the active site is unoccupied) of the donor site or sites is long compared to the time necessary for the ternary complex to decompose, the concentration of the donor is said to be rate-limiting. Under such conditions the enzyme accumulates as the free enzyme (when the binary complex is donor-enzyme) or as the acceptor-enzyme complex (when the binary complex is acceptor-enzyme). The concentration of the free enzyme or binary complex becomes constant and, for all practical purposes, equal to the original enzyme concentration, i.e., the rate law becomes pseudo-monomolecular with respect to the donor concentration. Similarly, when the acceptor concentration is rate-limiting, the enzyme must accumulate either as free enzyme or as the donor-enzyme complex, and the rate law becomes pseudomonomolecular with respect to the acceptor concentration. When the enzyme concentration is rate limiting, i.e., when the free time of both donor and acceptor sites is short relative to the time necessary for the decomposition of the ternary complex, the enzyme accumulates as ternary complex, the concentration of which becomes constant and, for all practical purposes, equal to the original concentration of enzyme. In this case, the rate becomes constant and independent of both donor and acceptor concentration. In all three rate-limiting cases, the rate constant varies with change in the total enzyme concentration.

We shall restrict the term "stability of the complex" to mean stability against dissociation into the original reactants. Thus, the binary complex will be stable when its rate of formation and its rate of reaction to form the ternary complex are both at least ten times as great as the rate of dissociation of the binary complex. The sufficient condition for stability of the binary complex is that the rate of formation be at least ten times as great as its rate of dissociation. Similar conclusions hold for the ternary complex. A steady state is said to exist for a given reactant when the rate of formation is equal to its rate of utilization. This does not imply that either the rate of formation or the rate of utilization is constant as the reaction proceeds; it only implies a linear relation between the two rates. Steady-state equations are used to solve for the concentrations of all reactive intermediates in terms of the initial reactants. These values are then used to obtain the rate laws. The case in which all the reactions have rates of the same order of magnitude is not treated, since it is highly improbable. Instead, the rate laws are derived for five more probable cases in each class of enzymes. In order that the discussion of the mechanism of action of each class of oxidative-reductive enzymes may be followed uninterruptedly, the details of the mechanism, the simplified mechanism, and the special cases of

the rate law are all placed in a table at the end of the section devoted to each class.

C. Oxidases

1. Enzymes which reduce oxygen to hydrogen peroxide

The oxidases which reduce oxygen to hydrogen peroxide, producing the latter as a primary product, comprise the first class of oxidative enzymes. *d*-Amino-acid oxidase, xanthine oxidase, luciferase, and uricase are members of this class. Oxygen is the specific acceptor substrate in all cases, though in a few reactions some leuco dyes can replace oxygen. The specific donor substrate is given by the name of the oxidase.

Table 2 contains the detailed mechanism: the entire process proceeds through the univalent transfer of an electron from the donor to the enzyme forming an enzyme semiquinone; the latter then transfers its electron to the acceptor. This process is then repeated, resulting in a bivalent oxidation-reduction of the substrates.

If the enzyme has a coenzyme, the coenzyme may undergo a bivalent oxidation-reduction (cf. Section E), but the protein moiety of any oxidation-reduction enzyme is restricted to a univalent oxidation or reduction. The interatomic spacing of the site is critical. Formation of a semiquinone will not alter the spacing to any extent, for the electron is transferred across the protein to the

TABLE 2

Oxidase Reactions in Which the End Product Is H_2O_2

MECHANISM

$$RH_2 \rightleftharpoons H^+ + RH^- \rightleftharpoons 2H^+ + R^= \tag{1a}$$

$$RH_2 + E \rightleftharpoons RH_2 \cdot E \tag{2a}$$

$$RH_2 \cdot E \rightleftharpoons RH_2^+ \cdot E_s^- \rightleftharpoons RH \cdot E_s^- + H^+ \tag{3a}$$

$$RH \cdot E_s^- + O_2 \rightleftharpoons RH \cdot E_s^- \cdot O_2 \tag{4a}$$

$$RH \cdot E_s^- \cdot O_2 \rightleftharpoons RH \cdot E \cdot O_2^- \rightleftharpoons RH^+ \cdot E_s^- \cdot O_2^- \rightleftharpoons R \cdot E_s^- \cdot O_2^- + H^+ \rightleftharpoons R \cdot E \cdot HO_2^- \tag{5a}$$

$$R \cdot E \cdot HO_2^- \rightleftharpoons R + E + HO^- \tag{6a}$$

$$HO_2^- + H^+ \rightleftharpoons H_2O_2 \tag{7a}$$

SIMPLIFIED MECHANISM

$$RH_2 + E \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} E \cdot RH_2 \tag{1}$$

$$E \cdot RH_2 + O_2 \underset{k_{-2}}{\overset{k_2}{\rightleftharpoons}} RH_2 \cdot E \cdot O_2 \tag{2}$$

$$RH_2 \cdot E \cdot O_2 \xrightarrow{k_3} R + H_2O_2 + E \tag{3}$$

SPECIAL CASES OF THE RATE LAW

a. The complexes are very stable and do not tend to dissociate into their original components, i.e., k_{-1} and k_{-2} are negligible:

$$\frac{-d[RH_2]}{dt} = k_1[E][RH_2] \tag{A-1}$$

b. Donor concentration is rate-limiting:

$$\frac{-d[RH_2]}{dt} = k_1[E][RH_2] = k_1'[RH_2] \tag{A-2}$$

c. Acceptor concentration is rate-limiting:

$$\frac{-d[RH_2]}{dt} = k_2[E \cdot RH_2][O_2] = k_2'[O_2] \tag{A-3}$$

d. Enzyme concentration is rate-limiting:

$$\frac{-d[RH_2]}{dt} = k_3[O_2 \cdot E \cdot RH_2] = k_3' \tag{A-4}$$

e. The binary complex equilibrium controls the rate of the reaction and k_{-2} is negligible:

$$\frac{-d[RH_2]}{dt} = k_2K_1[E][RH_2][O_2] \tag{A-5}$$

prosthetic group or to the other site in a time of the order of 10^{-8} second. If a bivalent oxidation-reduction occurs on the active site, at least one of the sensitive interatomic distances will be altered, which would probably lead to inactivation of the enzyme.

In all oxidase reactions, we assume that the donor-enzyme complex forms the binary radical prior to reaction with oxygen (equation 3a), the free electron of the enzyme semiquinone being near or on the surface of the acceptor site. The reaction between oxygen and a free radical does not require a large activation energy—in all probability the first oxygen that strikes the active site will undergo reaction. This assumption does not require that the oxygen undergo a mysterious "activation" prior to reaction, and it does not demand a chain reaction or free semiquinone loose in the environment. The semiquinones (free radicals) are always combined with the enzyme, and their life is very short. The stability of the enzyme-donor binary radical complex is easily explained by resonance effects. Actually there is no reason why the oxygen molecule may not form a binary complex with the enzyme, provided no electron exchange takes place until the ternary complex is formed. The perhydroxyl ion, a co-partner in the ternary complex (cf. equation 5a), only exists for a period long enough for the first electron to be transferred to the acceptor, i.e., the order of 10^{-8} second. Hence, it does not have time to attack the enzyme before losing another electron. If the hydroperoxide ion remains attached to the enzyme very long (equations 5a, 6a), the enzyme is very likely to undergo an oxidation or reduction, thus inactivating the protein moiety.

In the detailed mechanism, the hydrogen-ion transfers shown are written in the order given, for convenience, but we do not mean to imply that they must occur at the particular stages of the reaction indicated.

When the donor or acceptor concentration is rate-limiting, the rate becomes pseudo-monomolecular with respect to the donor or acceptor, respectively (equation A-2 and equation A-3). When the enzyme concentration is rate-limiting, the rate becomes constant (equation A-4). When the equilibrium for binary complex formation is established so rapidly that it controls the concentration of the binary complex, and k_{-2} is negligible, the rate law for the reaction becomes that given by equation (A-5).

The mechanism given by Johnson, Eyring, Steblay, Chaplin, Huber and Gherardi (1945) for the liciferase-luciferin reactions, although not given in as much detail as these reactions, is very similar to the mechanism just mentioned. It is complicated by the light-emission reactions which also occur in that particular system.

2. Enzymes which reduce oxygen to water

The oxidases which reduce oxygen to water, producing the latter as a primary product, comprise the second class of oxidative enzymes. Laccase, tyrosinase, and *l*-ascorbic acid oxidase are members of this class. Oxygen is again the specific acceptor substrate for each enzyme.

The detailed mechanism is given in Table 3. The first five reactions are identical with those of the oxidases which reduce oxygen to hydrogen peroxide. The dissociation of the ternary complex following the bivalent oxidation-reduction, however, now gives oxidized donor and the binary complex ($HO_2^- \cdot E$) (equation 1b) in place of oxidized donor, free enzyme, and hydrogen peroxide. The binary complex ($HO_2^- \cdot E$) then combines with another donor molecule to form a ternary complex, which then undergoes a second series of univalent changes (equation 3b, 4b), producing a second oxidized donor molecule, the original enzyme, and two molecules of water (equation 4b, 5b). The binary complex ($HO_2^- \cdot E$) may, however, undergo an irreversible reaction which causes inactivation of the enzyme (equation 2b). The inactivation may take any of several routes: (1) internal oxidation-reduction of the hydroperoxide followed by dehydration, which will produce a ketonic linkage at the point of attachment to the enzyme; (2) internal oxidation-reduction of the hydroperoxide followed by loss of atomic oxygen, which will produce an alcoholic group at the point of attachment, and the atomic oxygen will probably oxidize some adjacent portion of the enzyme; (3) occurrence of a second oxidation resulting in the scission of the enzyme; or (4) formation of a radical which will form polymeric peroxide with another enzyme or initiate a chain polymerization of the enzyme. These four reaction paths leading to inactivation of the enzyme are those known to occur after formation of hydroperoxide in the chain autoxidation of hydrocarbons (Bolland and Gee, 1946; Gee, 1946; Farmer, 1946; Zuidema, 1946). If the ($HO_2^- \cdot E$)

complex does not combine with a donor molecule in a short interval of time, inactivation results.

This mechanism explains the pronounced inactivation of the enzymes of this class when they are not protected by catalase-active or peroxidase-active enzymes. *l*-Ascorbic acid oxidase is an excellent example for discussion. This oxidase catalyzes the oxidation of *l*-ascorbic acid by oxygen, with reduction of the oxygen to water (Hand and Greisen, 1942; Powers and Dawson, 1944; Powers, Lewis, and Dawson, 1944; Steinman and Dawson, 1942). The optimum pH for this reaction lies at pH 5.6. At this pH the monovalent ascorbate ion constitutes 97 per cent of the total ascorbic acid. As the cupric-ion catalysis of the autoxidation of *l*-ascorbic acid has been shown to proceed through the monovalent ascorbate ion (Weissberger and LuValle, 1944), it is reasonable to assume that the oxidase catalysis also involves the monovalent ascorbic ion. The rate data for the cupric-ion catalysis is best explained by formation of a complex between the cupric ion, oxygen, and the monovalent ascorbate ion; however, the end product of the cupric-ion catalysis is hydrogen

TABLE 3

Oxidase Reactions in Which the End Product Is H_2O

MECHANISM: Reactions (1a) through (5a) from Table 2 followed by:

$$HO_2^- \cdot E \cdot R \rightleftharpoons HO_2^- \cdot E + R \tag{1b}$$

$$HO_2^- \cdot E \rightarrow HOO - E \rightarrow \text{Inactive products} \tag{2b}$$

$$HO_2^- \cdot E + RH_2 \rightleftharpoons HO_2^- \cdot E \cdot RH_2 \rightleftharpoons HO_2^- \cdot E_s^- \cdot RH_2^+ \rightleftharpoons HO_2^- \cdot E_s^- \cdot RH + H^+ \rightleftharpoons OH^- + HO \cdot E \cdot RH \tag{3b}$$

$$HO \cdot E \cdot RH \rightleftharpoons HO \cdot E_s^- \cdot RH^+ \rightleftharpoons HO \cdot E_s^- \cdot R + H^+ \rightleftharpoons H_2O \cdot E \cdot R \rightleftharpoons H_2O + E + R \tag{4b}$$

$$H^+ + OH^- \rightleftharpoons H_2O$$

SIMPLIFIED MECHANISM: Reactions (1) and (2) followed by:

$$O_2 \cdot E \cdot RH_2 \xrightarrow{k_4} HO_2^- \cdot E + R + H^+ \tag{4}$$

$$HO_2^- \cdot E + RH_2 \underset{k_{-5}}{\overset{k_5}{\rightleftharpoons}} HO_2^- \cdot E \cdot RH_2 \tag{5}$$

$$HO_2^- \cdot E \cdot RH_2 \xrightarrow{k_6} E + R + H_2O + OH^- \tag{6}$$

$$HO_2^- \cdot E \xrightarrow{k_7} HOO \cdot E \rightarrow \text{Inactive products} \tag{7}$$

SPECIAL CASES OF THE RATE LAW

a. k_{-1}, k_{-5}, k_{-2} negligible, i.e., the complexes do not tend to dissociate into their original components to any extent:

$$\frac{-d[RH_2]}{dt} = k_1[E][RH_2] + \frac{k_1k_5[E][RH_2]^2}{k_7+k_5[RH_2]} \tag{B-1}$$

b. Donor concentration is rate-limiting:

$$\frac{-d[RH_2]}{dt} = k_1[E][RH_2] + k_5[HO_2^- \cdot E][RH_2] = [k_1' + k_5'][RH_2] = \text{const. } x[RH_2] \tag{B-2}$$

c. Acceptor concentration is rate-limiting:

$$\frac{-d[RH_2]}{dt} = k_2[E \cdot RH_2][O_2] = k_2'[O_2] \tag{B-3}$$

d. Enzyme concentration is rate-limiting:

$$\frac{-d[RH_2]}{dt} = k_4[O_2 \cdot E \cdot RH_2] + k_6[HO_2^- \cdot E \cdot RH_2] = k_4' + k' = \text{constant} \tag{B-4}$$

e. The binary complex equilibrium controls the rate of the reaction, and k_{-2} and k_{-5} are negligible:

$$\frac{-d[RH_2]}{dt} = k_2K_1[E][RH_2][O_2] + k_1[E][RH_2] \tag{B-5}$$

When reaction (7) is negligible, equation (B-1) becomes:

$$\frac{-d[RH_2]}{dt} = 2k_1[E][RH_2] \tag{B-1a}$$

peroxide. Therefore, the cupric-ion catalysis and the oxidase catalysis apparently differ in some respects. The evidence is rather strong against the intermediate formation of free hydrogen peroxide in the oxidase catalysis. Powers and Dawson (1944) found that catalase- or peroxidase-active enzymes protect ascorbic acid oxidase from inactivation, this protective power increasing with the concentration of enzyme. But the protective enzymes do not change the initial rate of oxygen uptake, and the end product remains water (Powers and Dawson, 1944). Furthermore, the peroxidase, even in ten times the concentration needed to show marked protective action, did not decompose H_2O_2 alone or at any significant rate in the presence of ascorbic acid. These data show that the protective enzymes do not destroy the hydrogen peroxide or the hydroperoxide, with formation of oxygen and water, although if the enzymatic activity of the protective enzymes is destroyed, the protective activity is also destroyed. Powers and Dawson also failed to find any evidence of a coupled oxidation of alcohol, such as that found by Keilin and Hartree (1936, 1945b). When catalase-active enzymes are added to the oxidases of the preceding section, however, the hydrogen peroxide is destroyed, with formation of water and oxygen. A discussion of the mode of protective action under these conditions is given later, following the discussion of the reaction mechanisms of peroxidase and catalase.

When the irreversible destruction of the enzyme is prevented, i.e., when equation (7) is negligible, the rate when the binary complex or all complexes are stable (equation B-1) reduces to a rate law identical in rate dependence with the rate laws of the previous section. The rate laws for the cases in which the concentrations of several reactants are rate-limiting hold only when equation (7) is negligible, for otherwise the concentration of the enzyme would be constantly decreasing. When the donor concentration is rate-limiting, the enzyme collects either as free enzyme and/or as the binary complex ($HO_2^- \cdot E$), and the concentration of both becomes constant; hence, the steady-state law is pseudo-monomolecular with respect to the donor concentration. The other cases are self-evident.

It might be argued that the oxidase adds two donor molecules prior to reaction with oxygen. If this constitutes the mechanism, it can easily be shown that the rate laws will be second-order with respect to the donor substrate. Lineweaver and Burke (1934) give graphical methods for determining the rate dependency in enzymatic reactions. We suspect that the majority of oxidase reactions proceed in the stepwise mechanisms outlined in these tables.

3. Enzymes which reduce oxygen to water but where donor substrate may undergo only a univalent change

This comprises a special case of B in which the donor may undergo only a univalent oxidation. Cytochrome C oxidase belongs in this class. Oxygen is the specific acceptor substrate and cytochrome C is the donor substrate.

The mechanism is outlined in Table 4. It is immediately apparent that the complexes, perhydroxyl-enzyme, $O_2^- \cdot E$, (eq. 3c), hydroperoxide-enzyme, $HO_2^- \cdot E$, (eq. 5c), and hydroxyl-enzyme, $HO \cdot E$, (eq. 7c), will tend to undergo spontaneous reactions leading to inactivation of the enzyme unless their free time before reacting with a donor molecule is very short. Cytochrome oxidase is known to be stable in mildly alkaline solutions in the absence of cytochrome C (Haas, 1943); this is to be expected if the oxygen reacts with the oxidase only after the formation of the oxidase-cytochrome binary complex. We should expect the oxidase to be more stable in the presence of excess cytochrome C, which is the condition necessary to keep the free time of the radical enzymes complexes very short. Unfortunately, we can find no direct evidence on this point. The rate laws for this mechanism are first-order with respect to donor and with respect to enzyme (eqs. C-1, C-2). This dependence coincides with the experimentally determined rate dependence. Therefore, the mechanism in which four donor molecules are attached to the enzyme prior to reaction with oxygen need not be considered, for the rate laws derived from this mechanism are fourth-order with respect to the donor molecules. The rate dependence with respect to oxygen has never been investigated completely. The other rate laws (eq. C-1 to C-5 inclusive) are self-evident. In the concentration-limiting cases, the enzyme distributes itself among all the complexes which react with the rate-limiting reactant (eqs. C-2 and C-4).

D. Peroxidases and Catalases

1. Peroxidases

Peroxidases and peroxidase-active enzymes are included in this class. Hydrogen peroxide acts as

TABLE 4

Oxidase Reactions in Which Water Is the End Product, but where the Donor Can Undergo Only a Univalent Oxidation or Reduction

MECHANISM

$$E + RH \rightleftharpoons E{\cdot}RH \tag{1c}$$
$$E{\cdot}RH \rightleftharpoons E_s^- \cdot RH^+ \tag{2c}$$
$$O_2 + E_s^- \cdot RH^+ \rightleftharpoons O_2 \cdot E_s^- \cdot RH^+ \rightleftharpoons O_2^- \cdot E \cdot RH^+ \rightleftharpoons O_2^- \cdot E + R + H^+ \tag{3c}$$
$$O_2^- \cdot E + RH \rightleftharpoons O_2^- \cdot E \cdot RH \rightleftharpoons O_2^- \cdot E_s^- \cdot RH^+ \rightleftharpoons O_2^- \cdot E + R + H^+ \tag{4c}$$
$$H^+ + O_2^- \cdot E \rightleftharpoons HO_2^- \cdot E \tag{5c}$$
$$HO_2^- \cdot E + RH \rightleftharpoons HO_2^- \cdot E \cdot RH \rightleftharpoons HO_2^- \cdot E_s^- \cdot RH^+ \rightleftharpoons HOE_2^- \cdot + R + H^+ \tag{6c}$$
$$HO_2^- \cdot E + H^+ \rightleftharpoons HO^- + HO \cdot E \tag{7c}$$
$$HO \cdot E + RH \rightleftharpoons HO \cdot E \cdot RH \rightleftharpoons HO \cdot E_s^- \cdot RH^+ \rightleftharpoons HO^- \cdot E \cdot RH^+ \rightleftharpoons HO^- + R + H^+ + E \tag{8c}$$
$$H^+ + OH^- \rightleftharpoons H_2O \tag{9c}$$

SIMPLIFIED MECHANISM

$$E + RH \underset{k_{-7}}{\overset{k_7}{\rightleftharpoons}} E{\cdot}RH \tag{7}$$
$$E{\cdot}RH + O_2 \underset{k_{-8}}{\overset{k_8}{\rightleftharpoons}} O_2 \cdot E \cdot RH \tag{8}$$
$$O_2 \cdot E \cdot RH \xrightarrow{k_9} O_2^- \cdot E + R + H^+ \tag{9}$$
$$O_2^- \cdot E + RH \underset{k_{-10}}{\overset{k_{10}}{\rightleftharpoons}} O_2^- \cdot E \cdot RH \tag{10}$$
$$O_2^- \cdot E \cdot RH \xrightarrow{k_{11}} O_2^- \cdot E + R + H^+; \; E \cdot O_2^- + H^+ \rightleftharpoons E \cdot HO_2^- \tag{11}$$
$$HO_2^- \cdot E + RH \underset{k_{-12}}{\overset{k_{12}}{\rightleftharpoons}} HO_2^- \cdot E \cdot RH \tag{12}$$
$$HO_2^- \cdot E \cdot RH \xrightarrow{k_{13}} HO \cdot E + R + HO^- \tag{13}$$
$$HO \cdot E + RH \underset{k_{-14}}{\overset{k_{14}}{\rightleftharpoons}} HO \cdot E \cdot RH \tag{14}$$
$$HO \cdot E \cdot RH \xrightarrow{k_{14a}} H_2O + E + R \tag{14a}$$

SPECIAL CASES OF THE RATE LAW

a. The complexes do not tend to dissociate into their original components, i.e., k_{-7}, k_{-8}, etc., are negligible:

$$\frac{-d[RH]}{dt} = 4k_7[E][RH] \tag{C-1}$$

b. Donor concentration is rate-limiting:

$$\frac{-d[RH]}{dt} = k_7[E][RH] + k_{10}[O_2^- \cdot E][RH] + k_{12}[HO_2^- \cdot E][RH] + k_{14}[HO \cdot E][RH]$$
$$= [k_7' + k_{10}' + k_{12}' + k_{14}'][RH] = \text{const. } x\,[RH] \tag{C-2}$$

c. Acceptor concentration is rate-limiting:

$$\frac{-d[RH]}{dt} = k_8[E \cdot RH][O_2] = k_8'[O_2] \tag{C-3}$$

d. Enzyme concentration is rate-limiting:

$$\frac{-d[RH]}{dt} = k_9[O_2 \cdot E \cdot RH] + k_{11}[O_2^- \cdot E \cdot RH] + k_{13}[HO_2^- \cdot E \cdot RH] + k_{14a}[HO \cdot E \cdot RH]$$
$$= [k_9' + k_{11}' + k_{13}' + k_{14a}'] = [\text{const.}] \tag{C-4}$$

e. The binary complex equilibrium controls the rate of the reaction, and k_{-8} is negligible:

$$\frac{-d[RH]}{dt} = 4k_8K_7[E][RH][O_2] \tag{C-5}$$

If any of the partially reduced enzyme-oxygen complexes undergo irreversible decomposition, these equations (C-1 through C-5) have to be modified as in the preceding section (2).

the acceptor and many substances, e.g., *l*-ascorbic acid, leuco-malachite green, etc., may act as the donor. The enzyme is specific toward hydrogen peroxide and rather unspecific toward its donor, at least in vitro.

The mechanism, as outlined in Table 5, differs from the mechanism of Section C-1 in that the acceptor-enzyme complex is formed first. The unspecificity toward the donor may be attributed to the formation of the binary radical, $E_x^+ \cdot OH$; hence, any donor which can attach itself to the donor site will undergo reaction if the redox potentials in the ternary complex are of the right order of magnitude. The unspecificity is also attributed in part to the shape of the donor site or sites. The rate laws are self-explanatory.

Chance's data (1943a, b) justify the stepwise mechanism outlined and, furthermore, confirm the rate law of eq. (D-1), i.e., the binary radical complex is very stable. The rate of decomposition of the ternary complex is so rapid that only the overall rate constant, k, of the reaction,

$$E \cdot H_2O_2 + RH_2 \xrightarrow{k} R + E + 2H_2O,$$

has been evaluated. Hence, k includes k_{16}, k_{-16} and k_{17}. The value of k, when leuco-malachite green or *l*-ascorbic acid is used as acceptor, is of the order of 10^5 liters mole^{-1} second^{-1} (Chance, 1943a).

TABLE 5

Peroxidase and Peroxidase-Active Enzymes

MECHANISM

$$E + H_2O_2 \rightleftharpoons E \cdot H_2O_2 \rightleftharpoons E_x^+ \cdot H_2O_2^- \rightleftharpoons E_x^+ \cdot OH + OH^- \quad (1d)$$

$$RH_2 + E_x^+ \cdot OH \rightleftharpoons RH_2 \cdot E_x^+ \cdot OH \rightleftharpoons RH_2^+ \cdot E \cdot OH \rightleftharpoons RH \cdot E \cdot OH + H^+ \quad (2d)$$

$$RH \cdot E \cdot OH \rightleftharpoons RH \cdot E_x^+ \cdot OH^- \rightleftharpoons RH^+ \cdot E \cdot OH^- \rightleftharpoons E + R + H^+ + OH^- \quad (3d)$$

$$H^+ + OH^- \rightleftharpoons H_2O \quad (4d)$$

SIMPLIFIED MECHANISM

$$E + H_2O_2 \underset{k_{-15}}{\overset{k_{15}}{\rightleftharpoons}} E \cdot H_2O_2 \quad (15)$$

$$E \cdot H_2O_2 + RH_2 \underset{k_{-16}}{\overset{k_{16}}{\rightleftharpoons}} RH_2 \cdot E \cdot O_2H_2 \quad (16)$$

$$RH_2 \cdot E \cdot H_2O_2 \xrightarrow{k_{17}} R + E + 2H_2O \quad (17)$$

SPECIAL CASES OF THE RATE LAW

a. k_{-15} and k_{-16} are negligible; i.e., complexes do not dissociate into original components to any extent:

$$\frac{-d[RH_2]}{dt} = k_{15}[E][H_2O_2] \quad (D\text{-}1)$$

b. Donor concentration $[RH_2]$ is rate-limiting:

$$\frac{-d[RH_2]}{dt} = K_{15}[E \cdot H_2O_2][RH_2] = k_{16}[RH_2] = \text{const. } x\ [RH_2] \quad (D\text{-}2)$$

c. Acceptor concentration, $[H_2O_2]$, is rate-limiting:

$$\frac{-d[RH_2]}{dt} = k_{15}[E][H_2O_2] = k'_{16}[H_2O_2] = \text{const. } x\ [H_2O_2] \quad (D\text{-}3)$$

d. Enzyme concentration is rate-limiting:

$$\frac{-d[RH_2]}{dt} = k_{17}[RH_2 \cdot E \cdot H_2O_2] = k'_{17} = \text{constant} \quad (D\text{-}4)$$

e. The binary complex equilibrium controls the rate of the reaction, and k_{-16} is negligible:

$$\frac{-d[RH_2]}{dt} = k_{16}K_{15}[E][RH_2][H_2O_2] \quad (D\text{-}5)$$

Slater and Goddard (1948) have recently given evidence that peroxidase acts as an oxidase in the plant. Assume that in the plant the enzyme combines with a specific coenzyme to form a binary complex which then forms a binary radical, in which (a) the enzyme may exist as a semiquinone, or (b) the iron atom of the porphyrin may be reduced to the ferro form. The binary radical then combines with oxygen, and a normal oxidase action takes place, the oxygen being reduced to

water or hydrogen peroxide. Carbon monoxide may either form a ternary complex at the active site (competitive inhibition) or form a complex with the ferrous iron which is not necessarily the active site.

2. Catalases

Catalase and other catalase-active enzymes comprise this class. Hydrogen peroxide acts as both acceptor and donor, except in coupled oxidations, where a short-chain alcohol or amine acts as donor.

The mechanism in which hydrogen peroxide plays the dual role of acceptor and donor is given in Table 6. This mechanism is similar to that of Sumner (1941) but radically different from that of other proposed mechanisms. The mechanism may be considered as similar to that of peroxidase, in which H_2O_2 replaces RH_2 (Sections II and III of Table 6), or the mechanism may proceed via the opposite preliminary step (Sections I and III of Table 6), or electron exchange may not take place until two H_2O_2 molecules are attached to the enzyme. If the binary complex does form a binary radical, however, it must form it via the peroxidase mechanism, for, in the coupled oxidations, the alcohol or amine acts as donor (Keilin and Hartree, 1945b). Keilin and Hartree (1936, 1945b) observed coupled oxidation only in the presence of a large excess of catalase over that required to destroy H_2O_2 by the mechanism of Sections II and III of Table 6; furthermore, the efficiency of the coupled oxidation is greatest when the hydrogen peroxide is supplied slowly. Their observations may be explained as follows: A coupled oxidation can take place only when the ratio of the catalase to the hydrogen peroxide concentration is so great that the probability of two hydrogen peroxide molecules being attached to one catalase molecule is very small. Under such conditions, the binary radical, $(E_s^+ \cdot OH)$, will react with the first molecule small enough to attach its oxidizable center to the vacant donor site of the catalase molecule. The unspecificity of the coupled oxidation lends added weight to this explanation.

The rate laws are self-explanatory. The experimentally determined first-order dependence with respect to enzyme and hydroperoxide is that given by eq. (E-1), i.e., the dissociation of the binary complex into its original components is negligible.

Protective Action for Other Enzymes. The protective action of catalase and peroxidase for the oxidases of group C-2 has not been explained. When catalase is added to a reaction mixture of an enzyme of group C-1, it protects the enzyme by destroying the hydrogen peroxide, with formation of water and gaseous oxygen; this may be called the normal protective action of catalase. When peroxidase is added to a reaction mixture of an enzyme of group C-1, it destroys the hydrogen peroxide, simultaneously oxidizing a donor molecule, with formation of water; this may be called the normal protective action of peroxidase. Powers and Dawson (1944) have shown that neither enzyme acts in the normal manner in the protection of oxidases of group C-2; furthermore, they have demonstrated that catalase does not cause a coupled oxidation of alcohol with oxidases of group C-2. They have suggested the following explanation: "The inaction of the oxidase may be due to some precursor of hydrogen peroxide; i.e., a 'redox' form of oxygen having a transitory existence because of performing some intermediary function in the enzymatic oxidation of ascorbic acid. It would be assumed that catalase and peroxidase have the ability to destroy this precursor at a high rate as long as they are enzymatically active, and that such decomposition would not affect the oxygen uptake or oxygen totals for complete oxidation of *l*-ascorbic acid."

Reference to Table 3 shows that perhydroxyl and hydroxyl radicals occur only in ternary complexes and that their life in the ternary complex is of the order of 10^{-8} seconds; hence, the effect of catalase or peroxidase upon either of these two radicals would be negligible. It follows that the protective action must be concerned with the binary complex of hydroperoxide-enzyme. Three possible explanations of the protective action are immediately apparent: (1) The irreversible destruction of the enzyme may lead to the formation of a radical which initiates enzyme polymerization; only a few enzyme molecules would need protection, and the normal protective action of catalase or of peroxidase would have a negligible effect upon the over-all kinetics of the ascorbic acid oxidation. (2) The oxidase and the catalase or peroxidase may form a complex in which the oxidase carries on its normal functions and is stabilized against destruction by the protective enzyme. (3) The hydroperoxide may be firmly bound to the oxidase, so that the protective enzyme forms a complex with the binary complex which is stabilized against

the irreversible reactions of destruction until a donor molecule is attached to the oxidase, at which point the catalase or peroxidase is released to stabilize another binary complex. Careful experimental work should enable a decision to be made on these three possibilities. This explanation does not require the presence of any special "redox" forms of oxygen in the reaction mixture.

TABLE 6

Catalase and Catalase-Active Enzymes

H_2O_2 is both donor and acceptor

MECHANISM

I Primary Step—Reduction of Enzyme

$$E + H_2O_2 \rightleftharpoons E\cdot H_2O_2 \rightleftharpoons E_s^-\cdot H_2O_2^+ \rightleftharpoons E_s^-\cdot HO_2 + H^+ \quad (1e)$$

$$HO_2\cdot E_s^- + H_2O_2 \rightleftharpoons HO_2\cdot E_s^-\cdot H_2O_2 \rightleftharpoons HO_2\cdot E\cdot H_2O_2^- \rightleftharpoons HO_2\cdot E\cdot OH + OH^- \quad (2e)$$

II Primary Step—Oxidation of Enzyme

$$E + H_2O_2 \rightleftharpoons E\cdot H_2O_2 \rightleftharpoons E_s^+\cdot H_2O_2^- \rightleftharpoons E_s^+\cdot OH + OH^- \quad (3e)$$

$$E_s^+\cdot OH + H_2O_2 \rightleftharpoons H_2O_2\cdot E_s^+\cdot OH \rightleftharpoons H_2O_2^+\cdot E\cdot OH \rightleftharpoons HO_2\cdot E\cdot OH + H^+ \quad (4e)$$

III Subsequent Reactions of $HO_2\cdot E\cdot OH$

$$HO_2\cdot E\cdot OH \rightleftharpoons HO_2^+\cdot E_s^-\cdot OH \rightleftharpoons HO_2^+\cdot E\cdot OH^- \rightleftharpoons E + O_2 + H^+ + OH^- \quad (5e)$$

$$H^+ + OH^- \rightleftharpoons H_2O \quad (6e)$$

SIMPLIFIED MECHANISM

$$E + H_2O \underset{k_{-18}}{\overset{k_{18}}{\rightleftharpoons}} E\cdot H_2O_2 \quad (18)$$

$$H_2O_2 + E\cdot H_2O_2 \underset{k_{-19}}{\overset{k_{19}}{\rightleftharpoons}} H_2O_2\cdot E\cdot H_2O_2 \quad (19)$$

$$H_2O_2\cdot E\cdot H_2O_2 \xrightarrow{k_{20}} E + 2H_2O + O_2 \quad (20)$$

SPECIAL CASES OF THE RATE LAW

a. Complexes do not dissociate into original components, i.e., k_{-18} and k_{-19} are negligible:

$$\frac{-d[H_2O_2]}{dt} = k_{18}[E][H_2O_2] \quad (E\text{-}1)$$

b. Donor concentration is rate-limiting; in this case, both donor and acceptor concentration will be rate-limiting simultaneously:

$$\frac{-d[H_2O_2]}{dt} = k_{18}[E][H_2O_2] + k_{19}[E\cdot H_2O_2][H_2O_2]$$

$$= [k'_{18} + k'_{19}][H_2O_2] = [\text{const.}][H_2O_2] \quad (E\text{-}2)$$

c. Same as b

d. Enzyme concentration is rate-limiting:

$$\frac{-d[H_2O_2]}{dt} = 2k_{20}[H_2O_2\cdot E\cdot H_2O_2] = 2k'_{20} = [\text{constant}] \quad (E\text{-}3)$$

e. The binary complex equilibrium controls the rate of the reaction, and k_{-19} is negligible:

$$\frac{-d[H_2O_2]}{dt} = k_{19}K_{18}[E][H_2O_2]^2 \quad (E\text{-}4)$$

E. Dehydrogenases and Carriers

1. Dehydrogenases

The dehydrogenases comprise this and the next class. These two classes are characterized by the behavior of the coenzyme as either donor or acceptor, according to the reaction under investigation. In the discussion of these enzymes, the coenzyme is regarded as a substrate for the dehydrogenases, for the following reasons: (1) The dehydrogenase will not function in the absence of the coenzyme. (2) The coenzyme is one of the reactants in the over-all reaction, e.g., the action of alcohol dehydrogenase of yeast:

$$\text{EtOH} + \text{Coenzyme 1} \rightleftharpoons \text{acetaldehyde} + \text{leuco-coenzyme 1.}$$

This is typical of all the dehydrogenases. The isolated coenzymes are few in number but one co-

TABLE 7
Dehydrogenases

I. Coenzyme acts as an acceptor

MECHANISM

$$RH_2 \rightleftharpoons H^+ + RH^- \rightleftharpoons R^{=} + 2H^+ \quad (10)$$

$$E + Co \rightleftharpoons E \cdot Co \rightleftharpoons E^+_s \cdot Co^- \quad (20)$$

$$RH_2 + E \cdot Co \rightleftharpoons RH \cdot E \cdot Co \rightleftharpoons RH^+_2 \cdot E^-_s \cdot Co \rightleftharpoons RH \cdot E \cdot Co^- + H^+ \rightleftharpoons RH \cdot E \cdot CoH \quad (30)$$

$$RH \cdot E \cdot CoH \rightleftharpoons RH^+ \cdot E^-_s \cdot CoH \rightleftharpoons R \cdot E \cdot CoH^- + H^+ \rightleftharpoons R \cdot E \cdot CoH_2 \rightleftharpoons R + E + CoH_2 \quad (40)$$

SIMPLIFIED MECHANISM

$$E + Co \underset{k_{-21}}{\overset{k_{21}}{\rightleftharpoons}} E \cdot Co \quad (21)$$

$$E \cdot Co + RH_2 \underset{k_{-22}}{\overset{k_{22}}{\rightleftharpoons}} RH_2 \cdot E \cdot Co \quad (22)$$

$$RH_2 E \cdot Co \xrightarrow{k_{23}} R + E + CoH_2 \quad (23)$$

SPECIAL CASES OF THE RATE LAW

a. Binary complex or both complexes are stable:

$$\frac{-d[RH_2]}{dt} = k_{21}[E][Co] \quad (F\text{-}1)$$

b. Donor concentration is rate-limiting:

$$\frac{-d[RH_2]}{dt} = k_{22}[E \cdot Co][RH_2] = k'_{22}[RH_2]. \quad (F\text{-}2)$$

c. Acceptor concentration is rate-limiting:

$$\frac{-d[RH_2]}{dt} = k_{21}[E][Co] = k'_{21}[Co] \quad (F\text{-}3)$$

d. Enzyme concentration is rate-limiting:

$$\frac{-d[RH_2]}{dt} = k_{23}[RH_2 \cdot E \cdot Co] = k'_{23} \quad (F\text{-}4)$$

e. The binary complex equilibrium controls the rate, and k_{-22} is negligible:

$$\frac{-d[RH_2]}{dt} = k_{22}K_{21}[E][Co][RH_2] \quad (F\text{-}5)$$

II. Coenzyme acts as a donor

MECHANISM

$$E + CoH_2 \rightleftharpoons E \cdot CoH_2 \rightleftharpoons E^-_s \cdot CoH^+_2 \quad (50)$$

$$A + E \cdot CoH_2 \rightleftharpoons A \cdot E \cdot CoH_2 \rightleftharpoons A \cdot E^-_s \cdot CoH^+_2 \rightleftharpoons A^- \cdot E \cdot CoH + H^+ \rightleftharpoons AH \cdot E \cdot CoH \quad (60)$$

$$AH \cdot E \cdot CoH \rightleftharpoons AH \cdot E^-_s \cdot CoH^+ \rightleftharpoons AH^- \cdot E \cdot Co + H^+ \rightleftharpoons AH_2 \cdot E \cdot Co \rightleftharpoons AH_2 + E + Co \quad (70)$$

SIMPLIFIED MECHANISM

$$E + CoH_2 \underset{k_{-24}}{\overset{k_{24}}{\rightleftharpoons}} E.CoH_2 \quad (24)$$

$$E \cdot CoH_2 + A \underset{k_{-25}}{\overset{k_{25}}{\rightleftharpoons}} A \cdot E \cdot CoH_2 \quad (25)$$

$$A \cdot E \cdot CoH_2 \xrightarrow{k_{26}} AH_2 + E + Co \quad (26)$$

SPECIAL CASES OF THE RATE LAWS

a. Binary complex or both complexes are stable:

$$\frac{-d(A)}{dt} = k_{24}[E][CoH_2] \quad (F\text{-}6)$$

TABLE 7—*Concluded*

b. Donor concentration is rate-limiting:

$$\frac{-d[A]}{dt} = k_{2a}[E][CoH_2] = k'_{2a}[CoH_2] \qquad \text{(F-7)}$$

c. Acceptor concentration is rate-limiting:

$$\frac{-d[A]}{dt} = k_{2b}[A][E\cdot CoH_2] = k'_{2b}[A] \qquad \text{(F-8)}$$

d. Enzyme concentration is rate-limiting:

$$\frac{-d[A]}{dt} = k_{2c}[A\cdot E\cdot CoH_2] = k'_{2c} \qquad \text{(F-9)}$$

e. The binary complex equilibria control the rate, and k_{-2b} is negligible:

$$\frac{-d[A]}{dt} = k_{2b}K_{2d}[E][Co][A] \qquad \text{(F-10)}$$

enzyme may function with several enzymes; e.g., "coenzyme 1 is the coenzyme for some 35 different enzymic reactions" (Sumner and Somers, 1947). This observation has led certain investigators (Warburg, 1938) to the view, that in the cell, *the coenzyme may act as a donor with one enzyme and then dissociate from the first enzyme and act as an acceptor with a second enzyme; i.e., the coenzymes act as electron-transfer agents between the dehydrogenases.* Many enzymes belong in this group, e.g., Robison ester dehydrogenase, malic acid dehydrogenase, glycerophosphate dehydrogenase, etc. Xanthine oxidase and *d*-amino-acid oxidase are also actually dehydrogenases, but as there is some question regarding the activity of the coenzyme in the oxidase reaction, we have placed these enzymes in both group C-1 and group E-1. In the discussion of group C-1, the coenzyme, together with the protein of these two oxidases, is treated as a molecular entity.

Table 7 contains the mechanism and rate laws applying to this group. In Part I, the mechanism and the rate laws are developed for the case in which the coenzyme acts as an acceptor, and in Part II, the mechanism and rate laws are developed for the case in which the coenzyme acts as a donor. The rate laws are self-evident, being identical in form with those given for the other groups of enzymes.

In these mechanisms, the formation of the binary radical complex of enzyme-coenzyme prior to formation of the ternary complex probably explains the unspecificity of some of the dehydrogenases. The rates of these reactions may be followed by the change in light absorption at 3400 Å, for the leuco-coenzyme absorbs markedly at this wave length, whereas the oxidized coenzyme does not absorb. Negelein and Wulff (1937b) have followed the kinetics of the alcohol-acetaldehyde system at different concentrations of reactants, products, and coenzyme concentrations.

2. Flavoproteins

This class is really a special case of the preceding group and includes those dehydrogenases which reduce cytochrome, such as cytochrome reductase, succinic dehydrogenase, lactic dehydrogenase of yeast, glycerophosphate dehydrogenase No. 2, and formic dehydrogenase. Cytochrome may undergo only a univalent reduction; hence, each of these enzymes must be capable of remaining combined with the coenzyme semiquinone, CoH, in the complex, (E·CoH), until a second cytochrome forms a ternary complex. This implies that the coenzyme semiquinone must be stable in the complex.

Table 8 contains the mechanism and rate laws for the reaction when the coenzyme acts as donor. The mechanism and rate laws for the case in which the coenzyme acts as an acceptor are given in Part I of Table 7, for the latter action is not limited to donors which can undergo only a univalent oxidation. The rate laws are self-evident. We use the symbol RH^+ or R for the oxidized cytochrome C, and RH for the reduced cytochrome C; i.e., the same symbols as those used in Section C.

A typical example has been worked out for glucose-1-PO_3H_2; its dehydrogenase, coenzyme II, cytochrome reductase, and cytochrome C, by Haas, Hogness, and their collaborators (1940, 1942). They followed the activity by the rate of reduction of cytochrome C at 5500 Å, a wave length at which ferrocytochrome C absorbs more strongly than the ferri-form.

The alloxazine coenzyme group of cytochrome reductase is very strongly bound to the protein,

K = 10^{-9}, i.e., many biochemists consider it a prosthetic group rather than a coenzyme. It is rapidly reduced by coenzyme II, k = 170 × 10^6 liter $mole^{-1}$ $minute^{-1}$, and is rapidly oxidized by cytochrome C, k = 5,300 × 10^6 liter $mole^{-1}$ $minute^{-1}$. Although the reductase is also oxidized by oxygen, k = 0.008 × 10^6, the action of cytochrome C is 10^6 times as fast, and it is therefore probable that oxidation by oxygen does not play a physiological role.

TABLE 8

Coenzyme Acts as Donor

MECHANISM

$$E + CoH_2 \rightleftharpoons E\cdot CoH_2 \rightleftharpoons E_a^-\cdot CoH_2^+ \quad (1g)$$

$$E\cdot CoH_2 + R \rightleftharpoons R\cdot E\cdot CoH_2 \rightleftharpoons R\cdot E_a^-\cdot CoH_2^+ \rightleftharpoons R^-\cdot E\cdot CoH_2^+ \rightleftharpoons RH + E\cdot CoH \quad (2g)$$

$$E\cdot CoH + R \rightleftharpoons R\cdot E\cdot CoH \rightleftharpoons R\cdot E_a^-\cdot CoH^+ \rightleftharpoons R^-\cdot E\cdot CoH^+ \rightleftharpoons E + Co + RH \quad (3g)$$

SIMPLIFIED MECHANISM

$$E + CoH_2 \underset{k_{-27}}{\overset{k_{27}}{\rightleftharpoons}} E.CoH_2 \quad (27)$$

$$R + E.CoH_2 \underset{k_{-28}}{\overset{k_{28}}{\rightleftharpoons}} R.E.CoH_2 \quad (28)$$

$$R.E.CoH_2 \xrightarrow{k_{29}} RH + E.CoH \quad (29)$$

$$R + E.CoH \underset{k_{-30}}{\overset{k_{30}}{\rightleftharpoons}} R.E.CoH \quad (30)$$

$$R.E.CoH \xrightarrow{k_{31}} E + Co + RH \quad (31)$$

SPECIAL CASES OF THE RATE LAWS

a. Binary complex or both complexes are stable:

$$\frac{-d[A]}{dt} = 2k_{27}[E][CoH_2] \quad (G\text{-}1)$$

b. Donor concentration is rate-limiting:

$$\frac{-d[A]}{dt} = k_{27}[E][CoH_2] = k'_{27}[CoH_2] \quad (G\text{-}2)$$

c. Acceptor concentration is rate-limiting:

$$\frac{-d[A]}{dt} = k_{28}[R][E\cdot CoH_2] + k_{30}[R][E\cdot CoH] = [k'_{28} + k'_{30}][R] = \text{constant } x\ [R] \quad (G\text{-}3)$$

d. Enzyme concentration is rate-limiting:

$$\frac{-d[A]}{dt} = k_{29}[R\cdot E\cdot CoH_2] + k_{31}[R.E\cdot CoH] = k'_{29} + k'_{31} = \text{constant} \quad (G\text{-}4)$$

e. The binary complex equilibrium controls the rate of the reaction, and k_{-28} is negligible:

$$\frac{-d[RH_2]}{dt} = k_{28}K_{27}[E][R][CoH_2] \quad (G\text{-}5)$$

F. Discussion

The mechanisms and rate data for all enzymes of oxidation-reduction can be summarized under two general mechanisms: In the first mechanism, the binary complex is formed from enzyme and donor; in the second mechanism, the binary complex is formed from enzyme and acceptor. The resulting rate laws are summarized in Table 9.

In cytochrome oxidase reactions, the radical complexes, O_2^-E and $HO\cdot E$, and the hydroperoxide complex, $HO_2^-\cdot E$, have a lifetime equal to the activated collision frequency per enzyme molecule. The activation energy for reaction of these complexes with cytochrome C should be very low; hence, their free life may be kept short if the cytochrome C is present in excess. These complexes would tend to destroy the enzyme if they remained free very long. In cytochrome reductase, the flavin coenzyme is capable of forming a stable semiquinone in the enzyme-coenzyme complex, and would therefore tend to be rather stable to reaction except with the acceptor substrate or substrates. The stability of the binary complex is

attributed primarily to the localization of the free electrons on: (a) the acceptor site or the bound acceptor substrate, and (b) the donor site or the bound donor substrate; hence, only those molecules which can enter the site will undergo reaction.

An enzyme is probably highly specific toward the substrate with which it forms the binary complex and less specific toward the substrate with which it forms the ternary complex. Once the binary radical is formed, it will react with any reactive substrate that enters the vacant site which can form chemical bonds with the active centers of the site, such that electrons can be transferred.

The enzyme sites may be visualized as shaped in such a manner that the substrates are oriented into the proper position for formation of the chemical bonds, as they approach the site. Under such conditions the redox potentials within the complex are such that univalent electron exchange occurs easily. These redox potentials are not necessarily the same as the redox potentials of the free substances. Since all electron exchanges are assumed to take place within the complex, it is not strange that reversible electrode potentials cannot be obtained without the use of mediators.

If the conditions of equation (H-1) hold, it is

TABLE 9

Summarized Rate Laws for Enzymes of Oxidation-Reduction

k_a and k_{-a} are rate constants for formation and dissociation of the binary complex.
k_b and k_{-b} are rate constants for formation and dissociation of the ternary complex.
k_c is the rate constant for formation of the products from the ternary complex.

	Binary complex is $[E \cdot RH_2]$	Binary complex is $[E \cdot A]$	
a. The binary complex is stable, i.e., k_{-a} is negligible:	$\frac{-d[RH_2]}{dt} = \frac{d[A]}{dt} = k_a[E][RH_2]$	$k_a[E][A]$	(H-1)
b. The ternary complex is stable, i.e., k_{-b} is negligible:	$\frac{-d[RH_2]}{dt} = \frac{d[A]}{dt} = \frac{k_a k_b[E][RH_2][A]}{k_{-a}+k_b[A]}$	$\frac{k_a k_b[E][A][RH_2]}{k_{-a}+k_b[RH_2]}$	(H-2)
c. Donor concentration is rate-limiting:	$\frac{-d[RH_2]}{dt} = \frac{d[A]}{dt} = k'_a[RH_2] = k_a[E][RH_2]$	$k'_b[RH_2] = k_b[E \cdot A][RH_2]$	(H-3)
d. Acceptor concentration is rate-limiting:	$\frac{-d[RH_2]}{dt} = \frac{d[A]}{dt} = k'_b[A_2] = k_b[E][RH_2][A]$	$k'_a[A] = k_a[E][A]$	(H-4)
e. The binary complex equilibrium is rate-controlling, and k_{-b} is negligible:	$\frac{-d[RH_2]}{dt} = \frac{d[A]}{dt} = k_b K_a[E][RH_2[A]$	$k_b K_a[E][RH_2][A]$	(H-5)
f. Enzyme concentration is rate-limiting:	$\frac{-d[RH_2]}{dt} = \frac{d[A]}{dt} = k'_c = k_c[A \cdot E \cdot RH_2]$	$k'_c = k_c[A \cdot E \cdot RH_2]$	(H-6)

The rate of reaction with the several substrates will vary, depending upon redox potentials within the complex and the ease of entering the site.

Although the coenzyme of cytochrome reductase can be oxidized by both oxygen and cytochrome C, the rate with cytochrome C is 10^6 times the rate with oxygen (Haas et al., 1942). Peroxidase is highly specific toward hydrogen peroxide but very unspecific toward its donor substrate (Chance, 1943a). Catalase will also accept donors other than hydrogen peroxide, if the concentration of the latter is so small that the probability of more than one peroxide molecule being attached to one catalase molecule is very low (Keilin and Hartree, 1936, 1945b).

easily seen that the first-order dependence upon the "binary complex" *substrate* (acceptor or donor) is due to the equilibrium being highly in favor of the complex. This also explains why the "ternary complex" *substrate* (donor or acceptor) often apparently has no effect upon the rate of the reaction.

V. EXTENDED MICHAELIS-MENTON THEORY

The development of the concepts utilized in the previous section has led to an extension of the Michaelis-Menton theory (1913). The two basic assumptions of this theory are: (1) The equation,

$$E + RH_2 \rightleftharpoons E \cdot RH_2 \qquad (32)$$

represents the equilibrium between enzyme and

donor, where the fraction of RH_2 combined in the enzyme is small relative to the total (RH_2). (2) The rate of the reaction is proportional to the concentration of $E \cdot RH_2$. The Michaelis constant, K_m, is given by the formula:

$$K_m = \frac{[E][RH_2]}{[E \cdot RH_2]} \tag{33}$$

Let the total enzyme present = $E_T = E + E \cdot RH_2$; then,

$$[E \cdot RH_2] = [E_T] \frac{[RH_2]}{K_m + [RH_2]} \tag{34}$$

i.e., the rate is proportional to the total enzyme concentration. When $K_m = [RH_2]$, $[E \cdot RH_2] = [E] = 1/2[E_T]$; therefore, K_m is equal to the concentration of the donor substrate which gives half maximal velocity for the given concentration of enzyme.

Michaelis and Menton did not consider the acceptor in their discussion. We shall now derive the Michaelis constants for donor and acceptor in terms of the mechanisms summarized in Table 9. (The following treatment is modeled after that used by Van Slyke, 1942, in his discussion of the original Michaelis-Menton theory.)

Let the acceptor be in large excess, i.e., a variation of the donor concentration from zero to a value sufficient to make the enzyme concentration rate-limiting will not cause the acceptor concentration to become rate-limiting. For convenience, let the binary complex be $E \cdot RH_2$; then, equation (H-3) gives the rate when the donor concentration is rate-limiting and equation (H-5) when the enzyme concentration is rate-limiting. At half maximal velocity,

$$(RH_2)_{v_m/2} = \frac{k_c}{k_a} \tag{35}$$

for

$$(E)_{v_m/2} = (A \cdot E \cdot RH_2)_{v_m/2} = 1/2(E_T) \tag{36}$$

and the half maximal velocity is given by

$$\left[\frac{-d(RH_2)}{dt}\right]_{v_m/2} = \frac{1/2(E_T)k_a(RH_2)_{v_m/2}}{1 + k_a(RH_2)_{v_m/2}} = 1/2 \frac{k_c}{1 + k_c}(E_T) \tag{37}$$

If the donor is in large excess, then equations (H-4) and (H-5) show that at half maximal velity:

$$[A]_{v_m/2} = \frac{k_c}{k_b} \tag{38}$$

for $[RH_2 \cdot E] = [A \cdot E \cdot RH_2] = 1/2[E_T]$ (39)

and

$$\left[\frac{-d[RH_2]}{dt}\right]_{v_m/2} = 1/2[E_T] \frac{k_b[A]_{v_m/2}}{1 + k_b[A]_{v_m/2}} = 1/2 \frac{k_c}{1 + k_c}[E_T] \tag{40}$$

But then the half maximal velocity in the presence of a large excess of donor is identical with the half maximal velocity in the presence of a large excess of acceptor. This result is independent of the nature of the binary complex, i.e., $[E \cdot RH_2]$ or $[A \cdot E]$. Now

$$K_a = \frac{1}{K'_a} = \frac{[E \cdot RH_2]}{[E][RH_2]} = \frac{1}{[RH_2]_{v_m/2}} \tag{41}$$

and

$$K_b = \frac{1}{K'_b} = \frac{[A \cdot E \cdot RH_2]}{[A][E \cdot RH_2]} = \frac{1}{(A)_{v_m/2}} \tag{42}$$

Therefore, K'_a and K'_b are the Michaelis constants for the donor and the acceptor, respectively, and K_a and K_b are the corresponding affinity constants. If $A \cdot E$ were the binary complex, the constants, K'_a and K'_b, would be reversed, as would the constants, K_a and K_b. It does not follow that K_a and K_b are of the same order of magnitude. In all probability, the evaluation of the Michaelis constant for the substrate which combines with the binary complex will be very difficult, for its maximal velocity may be attained at very low concentrations. However, these two constants do offer an experimental method for the determination of the occurrence of ternary complexes in enzymatic reactions.

We might define the activity of a given enzyme preparation:

$$\text{Activity} = [RH_2]_{v_m/2} \frac{[A]_{v_m/2}}{[E_T]} \tag{43}$$

where $[RH_2]$ and $[A]$ are in moles per liter and E_T in grams dry weight of enzyme per liter. Similarly, the affinity of an enzyme for its substrates could be defined:

$$\text{Affinity} = \frac{[E_T]}{[RH_2]_{v_m/2}[A]_{v_m/2}} = \frac{1}{\text{Activity}} \tag{44}$$

These definitions of the activity and affinity include all the data necessary to define a given enzyme.

Chance (1943a, b) has shown that the Michaelis theory not only explains the data in the steady state but also explains the data in the transient

portions of the rate curves. Chance's data also clearly show that the rate is a function of enzyme, acceptor, and donor concentrations. In the region where H_2O_2 concentration is rate-limiting, the rate is pseudomonomolecular with respect to hydrogen peroxide, and in the region where the donor concentration is rate-limiting, the rate is pseudomonomolecular with respect to the donor concentration. If the hydrogen peroxide concentration or the donor concentration is increased to values such that the enzyme concentration is rate-limiting, the rate becomes constant. Unfortunately, Chance's data as published do not permit the calculation of the Michaelis constant for the donor independent of the constant for the acceptor.

VI. CONCLUSIONS

While this paper was in preparation, Michaelis (1946) and Kalckar (1946) published articles in which they also proposed ternary complex formation involving the formation of semiquinones within the complex. Neither author had, however, carried his ideas as far as we have developed ours in this paper. Admittedly much of the discussion is speculative; however, the correlations which have come out of these speculations show that a very complete investigation of ternary complex formation is needed. There are already available sufficient data to justify the presentation of this hypothesis. It has the threefold advantage of (1) reducing all enzymic oxidation-reduction processes to one basic mechanism; (2) permitting the enzyme to retain its specificity while producing semiquinones and radicals; and (3) explaining oxidase reactions without the use of oxygen activation.

The comparison of the chemical reactions of an atom or molecule in a complex with its chemical reactions in another complex for the purpose of deciding the oxidation state of the atom or molecule is apt to be highly misleading. The atom or molecule in the first complex may be in the same oxidation state as the atom or molecule in the second complex, and yet exhibit utterly different properties. For instance, there are several heme proteins, but only hemoglobin acts as an oxygen-carrier. Carbon monoxide inhibition of a heme enzyme does not necessarily imply that iron in the heme enzyme is in the same oxidation state as that in hemoglobin. Other evidence, such as magnetic susceptibility measurements and absorption spectra, is needed before a conclusion may be reached.

A great deal of experimental work is needed to verify the conclusions we have reached with respect to complex formation in enzymic reactions. Some phases of the experimental approach to the problem of enzyme mechanism follow:

a. The determination of the values of the Michaelis constants for substrate and acceptor may require carefully controlled experiments, but not apparatus of a complex nature. These experiments constitute the simplest test of the hypothesis.

b. The question of hydrogen transport may be settled by the use of deuterium or tritium in enzymic reactions. Substances used must have low exchange rates with the solvent. If there is a direct transfer, not involving ionization into the solvent, the acceptor will be much richer in the isotope than the solvent. If ionization is involved in hydrogen transport, the isotope ratio of solvent and acceptor will be equal.

c. With use of labeled coenzyme molecules, it will be possible to determine the carrier role of the coenzyme. The use of such substances will involve the problem of synthesis of the coenzyme.

d. Flow machines similar to Chance's design may be used to investigate the mechanism of complex formation. Such information will prove of great value.

e. Inhibition investigations will give us some information regarding the shape and size of the active sites.

f. Correlative studies of the kinetics and thermodynamics of reactions in the presence and absence of enzymes and in the presence of other catalysts should be made wherever feasible.

g. All the techniques now available for structure determination should be applied to enzymatic proteins.

h. The construction of a double-beam infrared flow machine should be of great value in following the changes within the complexes, provided the solvent is not too opaque.

i. Micromagnetic experiments may help identify the binary radicals.

The experiments just outlined should increase our knowledge of enzyme mechanisms to some extent. We believe that all enzymes use at least two substrates, but the mechanism, for example, for proteolytic enzymes, is not necessarily the same as the mechanism for oxidative-reductive enzymes. The mechanisms proposed here are restricted to enzymes of oxidation-reduction.

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NEW BIOLOGICAL BOOKS

The aim of this department is to give the reader brief indications of the character, the content, and the value of new books in the various fields of Biology. In addition there will occasionally appear one longer critical review of a book of special significance. Authors and publishers of biological books should bear in mind that THE QUARTERLY REVIEW OF BIOLOGY *can notice in this department only such books as come to the office of the editor. The absence of a book, therefore, from the following and subsequent lists only means that we have not received it. All material for notice in this department should be addressed to H. B. Glass, Assistant Editor of* THE QUARTERLY REVIEW OF BIOLOGY, *Department of Biology, The Johns Hopkins University, Baltimore 18, Maryland, U. S. A.*

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GENERAL BIOLOGY: PHILOSOPHY AND EDUCATION

SCIENCE AND REALITY.

By T. Bedford Franklin. G. Bell and Sons, London. 3s. 6d. vi + 56 pp. 1947.

Somewhere the reviewer has read the statement that the modern scientist writes like a philosopher, and that the modern philosopher writes like a scientist. The author of *Science and Reality* disclaims being either a scientist or a philosopher, but he writes both scientifically and philosophically. His book takes the form of a dialog between a scientist and Mr. X, that searcher after knowledge created by Sir Arthur Eddington in *The Nature of the Physical World.*

The relationship between the scientist and Mr. X is not that of teacher and pupil. The scientist, like Mr. X himself, is conscious of his own intellectual limitations, and makes his contribution to the joint symposium with humility and reverence. He is not to be compared with Jonas in the Rollo books, or with Rosamond's mother in Maria Edgeworth's *Early Lessons,* but rather with the Canterbury pilgrim of whom Chaucer stated, "Gladly would he learn, and gladly teach." He welcomes Mr. X to the museum which he has been rehabilitating to make it conform with the new quantum and relativity physics, and personally conducts him through room after room, explaining the exhibits. But he also gives Mr. X the opportunity to express his own opinions, and to offer suggestions, and listens courteously while Mr. X does so. Perhaps the participants are too polite to each other. Not that they resemble Gaston and Alphonse from the comic strip of an earlier generation, but merely that no issue between them is ever joined because there seems to be no issue that can be joined. For instance, in the penultimate chapter, where such a controversial subject as telepathy is considered, both participants admit the essential reasonableness of telepathic phenomena but both reject the demonstrations of telepathic communications given by professional clairvoyants. (Incidentally, is there such a word as telepathic? Should it not be telepathetic, after the analogy of sympathetic?)

The author has quoted extensively from Eddington, Jeans, and several less well known writers. Therefore perhaps he will permit one to quote from the final chapter of his work:

"Let us admit then that the ultimate reality is in the realm of the mind, for without mind the material world is purposeless and the spiritual world an unattainable ideal. The purpose of our life on Earth is the proper

use of mind, and the grafting on to our personalities of those values that come from the mind.

"To do this we have not got to be mathematicians, scientists, artists, poets, or philosophers or any of those people whom the ordinary man finds a little queer and incomprehensible. For the values to be sought are not mathematical formulae, scientific theories, or philosophical truths, but are simply Truth, Beauty, Goodness, and Love, and these are within the reach of us all."

To these words the reviewer repeats the loud Amen.

WHAT IS LIFE?

By J. B. S. Haldane. Boni and Gaer, New York City. $3.00. x + 241 pp. 1947.

This book should not be confused with another bearing the same title, by Erwin Schroedinger, already reviewed in these columns. It is a strange coincidence that these two books should have appeared within a year of each other. The one under discussion here consists of a series of separate essays most of which had already been published in daily newspapers. With a single exception they are all very brief, and one of the briefest is that which gives its title to the collection.

The author makes no attempt to answer the question which he poses in this essay. This is not because we do not know enough about life, but because we know too much. The experience of being alive is so fundamental that it cannot be defined in simpler terms. A definition of life would inevitably be somewhat similar to Dr. Samuel Johnson's definition of *network:* "Anything reticulated or decussated with equal intervals among the interstices." But if life cannot be defined satisfactorily, living matter may, although the task may be somewhat difficult. Yet it must be attempted if we are to learn to think scientifically when we consider ourselves, either our separate physiological activities or our corporate social reactions.

The author is thoroughly convinced that the social and political dilemmas which confront the civilized world today cannot be solved by anyone whose thinking lacks a scientific foundation. This thought has been expressed by earlier writers, notably Karl Marx, Friedrich Engels, and especially by Patrick Geddes. The reviewer gets the impression that Haldane owes more of his philosophy to Geddes, whom he does not quote at all, than to Marx and Engels, whom he quotes extensively.

In the United States, where few read Marx and Engels at all, and still fewer read either with intelligence, it is not customary to speak of these writers except disparagingly; but Haldane, who understands them perfectly, is able to discuss them without giving way to hysteria. For this reason the book is profitable reading for Americans, even for those not interested in the life sciences, and it deserves a wider circulation than it is likely to get.

Unfortunately, many of these essays were originally written some years ago, and have been reprinted here without the revision necessary to bring them up to date. For example, the author praises the Soviet Union for placing such an outstanding scholar as Vavilov in the presidency of the Soviet Academy, and he contrasts this action with that of the British government in forcing Harland, the leading geneticist of that nation, into exile in Peru, on grounds which a British jury held to be unjust. This comparison was justifiable when made, but it has subsequently become commonly believed, in this country at least, that as an aftermath of the controversy stirred up by Lysenko, Vavilov was sent to Siberia, where he died. If true, this would seem to indicate that in Russia politics thrusts its tentacles into the intellectual life of the people just as it does in England, or in our own country, as the persecution of Condon by the Thomas committee bears witness.

The only way to do adequate justice to a volume of this nature, from the pen of such a versatile genius as Haldane, would be to analyze each essay separately—but for such a task space and qualifications are lacking. Let it suffice to say that this is an extremely readable and withal important book, addressed not to the professional scientist but to the average reader, and expressed in language which does not degenerate to that level, affected by some popularizers of science, which insults the intelligence of its readers. Any one who undertakes to peruse this book will probably be as pleased with it as the reviewer has been.

BIOLOGY: HISTORY AND BIOGRAPHY

HOW MAN DISCOVERED HIS BODY. *A Young World Book.*

By Sarah R. Riedman; illustrated by Frances Wells. International Publishers, New York. $2.25. 128 pp.; text ill. 1947.

This book is a companion to the two outstanding books for 12-year-olds by Alex Novikoff, *Climbing Our Family Tree* and *From Head to Foot.* Written in a lively but simple style, and illustrated with graphic skill and humor, Sarah Riedman's book undertakes to tell the history of physiology in a way to make young readers appreciate the nature and methods of science and the hard effort and struggle against prejudice and error that underlie our present attainments. The story begins with man's curiosity and the belief in the power of magic. It moves on to consider the Greeks, Hippocrates and Aristotle; then the influence of Galen and the thousand years of darkness. Vesalius, Harvey, Leeuwenhoek, Malpighi, Stephen Hales and Robert Hooke, Priestley and Lavoisier, Réaumur, Spallan-

zani, Wm. Beaumont, Schleiden and Schwann, Morton, Claude Bernard, Galvani, Ferrier, Magendie and Bell are high-lighted in a procession of numerous others leading to such modern figures as Cannon, Hill, Banting, Loewi, and Pavlov. "So the unfinished story continues," the author concludes by saying.

Unfortunately, the standard of factual accuracy is not as high here as in Novikoff's companion books. The author has in several places said just the opposite of what she presumably meant. For example, William Harvey by dissection "... plainly showed that the veins on the right connected with the lungs, the ones on the left with the rest of the body." That is going to lead to no end of confusion in the mind of a 12-year-old reader! Again, "when this diaphragm and the muscles of the chest shorten, they pull on the covering of the lungs and make them stretch," is wording which would seem to imply that the diaphragm is directly attached to the lungs. And Leeuwenhoek, who wrote so many excellent, detailed letters about his observations to the Royal Society, would surely have been shocked to learn that a later generation would be told that "he refused to share his observations ... [because] he did not know how to write well." Such lapses are fortunately not too numerous; but they detract from an otherwise notable piece of science writing for the young.

BENTLEY GLASS

APERÇU DE L'HISTOIRE DE LA MÉDÉCINE EN BELGIQUE. *Collection Nationale, Seventh Series—Number 84. By Ernest Renaux, Albert Dalcq and Jean Govaerts. Office de Publicité, Bruxelles.* 25 fr. (paper). 84 pp. + 8 plates. 1947.

This little volume contains three short and competent essays on the development of the medical sciences in modern Belgium (which originated in 1831). The first division (by Dalcq) deals primarily with the remarkable work in embryology and cytology carried out by E. van Beneden, A. Brachet, and their pupils and contemporaries. The second division (by Govaerts) is devoted to modern Belgian surgery (E. Lambotte, and others). The third, Medicine and Experimental Sciences, by the editor E. Renaux himself, emphasizes the great contributions to practical and theoretical hygiene made in the pre-bacteriological era and later that are characterized by the names of Mayenne, van Ermengem, Malvoz, Bordet, and Gengou, among others. The fine physiological accomplishments of L. Frederic, P. Heger, etc., are shortly described. The importance of research in pure science for the development of practical medicine is stressed throughout the book. The little country has no dramatic invention to show, but in assimilating the best suggestions of her German and French neighbors, she has made a great number of very valuable contributions to science and has suceeded in maintaining unusually high standards. The booklet itself reflects this character of Belgian medical science.

ERWIN H. ACKERKNECHT

DOCTOR, DON'T LET ME DIE! *By S. S. Keiner; with the collaboration of Dan Gordon. Meador Publishing Company, Boston.* $3.50. 486 pp. 1947.

This is an autobiographical novel, the story of an average big city general practitioner, his studies, his interneship, his state board, the hungry first years, the patients, and so on. Everything looks cheap about this book to start with: the dust cover, the paper, the pompous dedication. And then one begins reading it, and cannot stop. The author is no great writer either, in the conventional sense. But with savage honesty he succeeds in giving so vivid a picture of all that is great and foul, sad and gay in this profession of ours in these days that at least most of those who have known, suffered, and loved medical reality will be fascinated and deeply moved. I have no doubt that this book contains more historical truth for future generations than a whole wagonload of the fashionable, fine biographies of contemporary medical leaders.

ERWIN H. ACKERKNECHT

DOUGLAS OF THE FIR. *A Biography of David Douglas, Botanist. By Athelstan George Harvey. Harvard University Press, Cambridge.* $4.00. x + 290 pp. + 6 plates; text ill. 1947.

David Douglas was one of a galaxy of brilliant explorer-naturalists produced in the British Isles during the late 18th and early 19th centuries. He was a contemporary of John Richardson, Thomas Drummond, John Franklin, Edward Parry, and George Back. These were the men who gathered the original material upon which our knowledge of the natural history of boreal and western America is based. The stirrings that took them afield were not limited to interests in natural history in the strict sense, but extended to the kindred spirits who carried the fur trade into the far Northwest—men such as Alexander Mackenzie and David Thompson. Even in so colorful a company, David Douglas was a brilliant figure into whose short tragic life was packed a volume of accomplishment, acclaim, and troubles not visited upon many men. He was killed in Hawaii in 1834, at the age of 35. In the twelve years between 1823 and 1835, he travelled extensively in eastern America, in the Columbia and Fraser River regions, in California, and in Hawaii.

He introduced 215 useful and ornamental plants to British gardens, and made extensive specimen collections of the flora, fauna, and minerals of the lands he visited. On one occasion he returned to England from the Columbia by way of Hudson Bay, travelling mostly afoot across the Rocky Mountains and the Canadian plains.

A. G. Harvey's biography is concise, well written, and splendidly documented. One wishes at times that he had developed the character of Douglas a little more freely, instead of leaving the reader to peer through and between the lines for glimpses of the actual man. This shortcoming, however, is adequately counterbalanced by the author's dispassionate treatment of the theme as a whole. One finishes the book with the feeling that he has been given, in an entertaining manner, all of the facts from which to build an acquaintance with a striking figure in botanical and exploratory history.

H. M. RAUP

TWO BLADES OF GRASS: *A History of Scientific Development in the U. S. Department of Agriculture.* *By T. Swann Harding. University of Oklahoma Press, Norman.* $3.50. xvi + 352 pp. 1947.

The author, a veteran writer and employee of the Department of Agriculture, has recorded the more valuable and sensational achievements of the Department's scientists from the early beginnings up to the present time. The history of the scientific agencies of the Department, and brief biographical sketches of some of the prominent scientists, are given. The work of famous men, including Theobald Smith, Marion Dorset, Maurice C. Hall, Harvey W. Wiley, Lore A. Rogers, Erwin F. Smith, M. B. White, L. O. Howard, W. O. Atwater, M. A. Carleton, and many others is given in considerable detail. The reader is regaled with a recital of the discoveries that led to the control of cattle tick fever, hog cholera, hookworm, and of many plant diseases. The introduction of numerous valuable plants, including Korean lespedeza, Acala cotton, Sudan grass, mosaic-resistant sugar canes, crested wheatgrass, Ladino clover, and Chinese (Mongolian) elm are listed. The breeding of hybrid corn and of disease-resistant varieties of wheat, oats, flax, cotton, sugar beets, and potatoes are recorded. Among the numerous scientific discoveries noted are photoperiodism, the technics of manufacturing sweet cream butter and Swiss cheese, and fermentation processes for making citric and gluconic acids. Items that are of more recent interest include the contributions of the Department to the application of D.D.T., penicillin, and 2,4-D. Researches in soils, forestry, wild life, and fertilizer manufacture are described. The genesis of the Pure Food Laws is recorded.

It is unfortunate that the shortness of the book did not permit mention of innumerable other important achievements. Topics omitted include the classic researches on soil moisture utilization, the establishment of scientific facts on dry farming to replace a host of impractical theories, the development of rices of superior cooking quality, the extension of flax, rice, and grain sorghum into new regions, the control of field bindweed, the determination of poisonous range plants, the breeding of crop varieties to fit them to machine harvesting, the breeding of smooth-awn barleys, and many others. The book includes no mention of the economic researches, even those of W. J. Spillman and O. E. Baker and their associates.

The book is surprisingly free from errors of fact and spelling. Among the discrepancies observed were a reference to the introduction of "upland" rather than lowland rice (p. 102), the crediting of research on apples to L. L. Harter instead of M. H. Haller, and the relegation of the latter, a contemporary worker in his prime, to the historical past.

Probably few research scientists in the Department will agree with the author's evaluation of the different administrations with regard to the encouragement and support of their work. Nonetheless, the author has prepared a valuable chronicle of progress in American agriculture.

JOHN H. MARTIN

MAYA EXPLORER: *John Lloyd Stephens and the Lost Cities of Central America and Yucatan.* *By Victor Wolfgang Von Hagen. University of Oklahoma Press, Norman.* $5.00. xviii + 324 pp. + 40 plates + 1 map; text ill. 1947.

This is the very entertaining, excellently written biography of a remarkable person who greatly stimulated the rise of American archeology. John Lloyd Stephens, an adventurous New York lawyer, business man, traveler, and diplomat, over a century ago rediscovered many of the now famous ancient centers of Mayan culture in Central America. As a young man he travelled to Greece, Egypt, and Arabia and in the latter part of his life he took a leading part in the construction of the Panama railway. He was born in New Jersey in 1805 and died in New York in 1852. Stephens' accounts of his Central American explorations, published in 1841 and 1843, created a tremendous interest in New World archeology, their appeal having been greatly enhanced by the many charming, remarkably accurate and detailed drawings, made by Stephens' faithful companion, the English artist Frederick Catherwood.

Even though the life of Stephens cannot be reconstructed completely, since many of his journals and much of his correspondence have become lost,

Von Hagen has succeeded admirably in bringing his hero back to life, giving him well deserved praise, and picturing vividly the romance and difficulties in the early exploration of the vanished Mayan civilization in jungle-hidden ruins. The text is enriched with 40 pages of fine illustrations from Catherwood's drawings and from modern photographs of corresponding scenes. There is a brief chronology of Stephens' life, an extensive bibliography, and an adequate subject index. Students of American archeology and all travelers to Central America will want to read this book and can be assured of pleasure and profit.

A. H. SCHULTZ

ECOLOGY AND NATURAL HISTORY

ONE DAY AT TETON MARSH.

By Sally Carrighar. Illustrations by George and Patritia Mattson. Alfred A. Knopf, New York. $3.50. viii + 239 pp. + 9 plates; text ill. 1947.

Like *One Day on Beetle Rock*, Sally Carrighar's first rich and delightful book of natural history, *One Day at Teton Marsh* portrays the same day in the lives of the animal habitants of a beaver pond and marsh alongside the rushing Snake River. Otter, cutthroat trout, and osprey appear first, followed by an interlude filled with the lives of tiny denizens of the willow cove—the mosquito and the scud. Mink, varying hare, merganser, and moose then play out their roles. Between acts the clepsine leech, leopard frog, and physa snail enact a lesser drama on the stage of a water-lily stalk and pad. The two final figures are the trumpeter swan and the beaver. The episodes reach a common climax in the animals' struggles to meet the crisis brought about by the fall of the dead cottonwood tree that supported the beaver-dam and the rapid emptying of the pond and draining of the marsh as a sequel.

The minute detail of the author's observations of these lives reveals a real naturalist, and the clarity and simplicity with which the author portrays them, free of human bias, is in the spirit of Henri Fabre. The closely interknit lives of these co-dwellers in the marsh blend in an ecological masterpiece that is as far as the Antipodes from the dullness of ecology textbooks. Descriptive biology is commonly regarded as outworn, dull, and unfruitful—and so much of it is. But this too is descriptive biology, and would that there were more of its like, in textbooks as well as out!

If there is a flaw in so fine a work, it is that of too evident a striving for fine language. At its best, Sally Carrighar's style is as fresh and full of tang as the air of the Tetons. Occasionally, in this book more than in her first, she strains for effect, becomes over-precious in choice of words or unusual sentence structure. Yet in other ways, *One Day at Teton Marsh* surpasses the earlier companion volume. There is more drama in these episodes, more unity in the conception as a whole, an intenser feeling of life. The woodcuts add much to the charm of the book.

BENTLEY GLASS

ANIMAL HOMES.

By George F. Mason. William Morrow and Company, New York. $2.00. 96 pp.; ill. 1947.

The diversity of animal homes is great. The dens of the larger animals, the burrows of the fox, the woodchuck, and the mole, the lodges of the muskrat and the beaver, the gall homes of insects, and the pebbly tunnels of the caddis fly larvae all reveal to an observer something of the habits, the needs, and even the personalities of their occupants. Through simple sketchings and words, George Mason has revealed much of the family life of the commoner American animals above, on, and below the ground and water levels. Written for junior readers, the slender volume gives a straightforward and factual, but never sentimental, account of the author's observations and excavations. It is a book that has much to recommend it.

C. P. SWANSON

CONTRIBUTION À L'ÉTUDE DU PEUPLEMENT DES ILES ATLANTIDES. *Société de Biogéographie. Mémoires—VIII.*

By P. and Mme V. Allorge, A. Badonnel, A. Balachowsky, L. Berland, L. Bertin, J. Bourcart, P. Bourrelly, A. Chevalier, L. Chopard, J. Denis, J. Feldmann, E. Fischer-Piette, P.-H. Fischer, A.-L. Guyot, R. Jeannel, P. Jovet, Mme S. Jovet-Ast, P. Lester, E. Manguin, P. Marie, A. Méquignon, Mme L. Paulian de Félice, P. de Peyerimhoff, R. Potier de la Varde, J. Rouch, M. Sorre, Mme Tardieu-Blot, D.-L. Uyttenboogaart, G. Viennot-Bourgin, R.-G. Werner. Paul Lechevalier, Paris. 1,600 fr. viii + 500 pp. + 13 plates + 2 maps + 1 chart; text ill. 1946.

Geography, geology, climatology, ethnography, zoology, and botany are represented in this collection of papers dealing with the Azores, Madeira, Canary, and Cape Verde Islands, and the small islets that surround them. The term oceanic island is used in a sense different than that in which Wallace originally defined it. The present definition limits this term to islands whose origin is bound with the formation of an ocean and which, at the beginning, had a connection with a continent. Volcanic islands are those that arose from the ocean depths and never had a continental connection. The Cape Verde, Canaries, and the Madeiras are considered continental, but the

Azores, oceanic. The geological history of these islands is discussed at great length and their physical structure is described in great detail, with maps for each island indicating stratigraphic formations. This information plus data on the climatology and oceanography of the area constitute the subject matter of the first three papers.

The remainder of the contributions are concerned with the faunistics of the islands, which have been studied with the hope of confirming or amending the geological evidence on the past history. With this view in mind the island faunas have been carefully compared with those of Europe, Africa, and North America. Unfortunately, there is still too little known on the zoology and botany of these areas as a whole—only certain groups have been fairly satisfactorily studied, and again, not equally well on all islands.

The invasion of these islands by man and the origin of these primitive inhabitants is the topic of the first paper on faunistics, which is followed by a second paper containing a similar discussion of the poikilotherms. The Coleoptera, which, of the invertebrates, seem to have been the best studied, is the topic for the next three papers. Following this are given the results of studies on the Orthoptera, Coccoidea, spiders, psocids, isopods, mollusks, Foraminifera, ferns, mosses, and algae. In the latter, incidentally, algologists will find some new forms described. To generalize the results of these studies would bring out multitudinous data that in itself would make a lengthy paper. To take an example from the cold-blooded vertebrates: there are no fresh-water fish on the islands except for the eel; no amphibians on the Cape Verde group, and only introduced species on the others; no snakes; only marine turtles (one doubtfully endemic species); many lizards. The latter include 29 species and subspecies of lacertids, skinks, and gekkos. A study of their distribution indicates that the Azores separated from the continent early (in the Oligocene or early Miocene) and did not profit from the rapid evolution of reptiles and amphibians that occurred later in Europe and Africa. The Madeiras and the Canaries have a predominantly Mediterranean fauna and the Cape Verde Islands an Ethiopian; these two groups separated early from each other. As a whole, the biota are more like the nearest continents than they are among the various islands, and they speak for different modes of invasion.

It is needless to point out that those interested in geology and zoogeography will find this publication a necessary reference. Although many of the discussions, especially those dealing with links to the West, are extremely valuable, the general impression is that there is still plenty of research remaining to be done in order to reach any final decision.

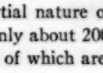
HENRI C. SEIBERT

DESERT PARADE. *A Guide to Southwestern Desert Plants and Wildlife.*

By William H. Carr; photographs by Marvin H. Frost. The Viking Press, New York. $2.50. 96 pp.; ill. 1947.

Desert Parade consists principally of brief notes on the habits and characteristics of some of the more common mammals, birds, reptiles, arthropods, and plants of the deserts of southwestern United States. It is illustrated with excellent photographs by Marvin H. Frost. The end papers carry a map of the Southwest showing desert areas, national parks and monuments, and principal highways. A few useful reference books are listed, and on the last page of the book is a brief discussion of the climate. The partial nature of the book is indicated by the fact that only about 200 species are mentioned, about 85 per cent of which are plants.

H. M. RAUP



PLANTS AND ENVIRONMENT. *A Textbook of Plant Autecology.*

By R. F. Daubenmire. John Wiley and Sons, New York; Chapman and Hall, London. $4.50. xiv + 424 pp.; ill. 1947.

According to the author's preface, "this book is an outgrowth of ten years' experience in teaching the fundamental relations between plants and environment to mixed classes of students majoring in botany, forest management, range management, and agriculture." The subject is approached through individually considered major environmental factors and the relations of plants to each of them. The point of view is that of practical field ecology, but with adequate regard for fundamental and theoretical aspects of factor relations. The text is thus one of autecology, which the author defines as "a consideration of those phases of geology, soils, climatology, zoology, chemistry, and physics which are more or less directly connected with the welfare of living organisms, and a relating of them to the structure, function, and evolution of [plant] species." This pronouncement is of course more inclusive than the text which follows. Daubenmire excludes "the several conflicting philosophies of plant sociology," and states what should be a truism in ecological teaching if it is not, that the study of plant communities must rest on "a working knowledge of the basic interrelationships between the individual plant and environment."

More than three-quarters of the text is devoted to soil, water, temperature, light, and atmospheric factors. The author's discussions of these factors are well organized, concise, and clear. Those fundamentals of soil science, meteorology, climatology, and physics vital to the work of the field ecologist are reviewed

Thus, although the organismic relations to environment dealt with here are those of plants, chapters on the aforementioned factors will be useful to students of animal ecology as important background information. There follow short chapters on biotic and fire factors and a brief terminal consideration of factor interrelations, "the environmental complex." The last chapter, Ecologic Adaptation and Evolution, although reading somewhat more like an addendum than an integral part of the text, serves to introduce the student to evolutionary aspects of ecological problems, mainly through the important recent work on plant ecotypes.

The basic approach of this text is essentially that of other recent ones which deal with plant autecology. Thus, no new contribution to the conceptual organization of the field has been made. But in avoiding controversial terminology and tenuous theory, the author has done a real service to teachers of ecology. Yet his attitude in this respect seems at times to have been too rigorous—for instance, although subject matter relating to vegetational change or succession is discussed by the author, I do not find the term "succession" used in the text, and it is not included in the index. This may be more of a hindrance than a help, as the term is both well established and useful. Also, the value of the text would have been enhanced by a descriptive chapter, even a brief one, on North American vegetation. To the reviewer, such a chapter seems as appropriate to a text on plant autecology as the terminal one on evolution. A field ecologist cannot avoid thinking in terms of natural vegetational units and here, controversial theoretics notwithstanding, the student must appeal to other sources.

Minor errors in text are few. Repetitions of fact, such as those on the value of data of mean annual temperature (pp. 183, 194) and the significance of low-temperature exposure to temperate-region perennials (pp. 196, 198), could have been avoided. At two points in chapter 9, except for different introductory sentences, text of more than a page-length is duplicated under two different headings. The illustrations are well chosen and clear. There is a 14-page index and a bibliography of 612 titles.

FRANK A. PITELKA

LE CLIMAT ÉCOLOGIQUE *de la Cuvette Centrale Congolaise.*

By Étienne Bernard. L'Institut National pour l'Étude Agronomique du Congo Belge, Bruxelles. 300 fr. (paper). 240 pp. + 1 chart, 2 maps; ill. 1945.

The Congo Basin is a region situated between 16° and 26° E longitude and 4° N and S latitude, with an elevation that rarely exceeds 500 meters. This depression is covered by an immense forest forming a fairly homogeneous band of vegetation. Since nothing, aside from local sporadic observations, is known regarding the climatology of this particular area, the present data, collected from a series of stations scattered over the Basin, provide much needed information.

Considerable emphasis has been placed on the energy of radiation, a factor of great ecological import, though too often neglected. Because of a rather high opacity, due to water vapor and impurities in the air, and a comparatively high nebulosity, the radiation values in the Congo Basin are scarcely greater than those found in temperate latitudes. The air temperature cycle has maxima at the equinoxes and minima at the solstices, being 31° and 20°C. respectively. Extremes rarely pass 36° and 17°C. Data on other important climatic factors, such as precipitation, evaporation, water vapor, and wind currents, are also included in the publication and are presented in the form of charts, tables, and diagrams. Each topic is thoroughly discussed. For such a large area, more first class observation stations would have been helpful, but the compiler seems to think that this fault is more or less alleviated by the general uniformity of the climate. It is to be hoped that this project will be continued with its present detailed objectives and that some of the difficulties encountered in making these original observations will be smoothed out. There is an extensive bibliography, an index, and two insert maps, one showing the geographic features of the Basin, and the other showing the climatic zones of Köppen. The latter appear to coincide well with the vegetational facies.

HENRI C. SEIBERT

CHEMICALS, HUMUS, AND THE SOIL. *A Simple Presentation of Contemporary Knowledge and Opinions about Fertilizers, Manures, and Soil Fertility.*

By Donald P. Hopkins. Chemical Publishing Company, Brooklyn. $8.50. x + 358 pp. + 1 plate; text ill. 1948.

About 20 years ago Albert Howard was director of the Indore Experiment Station, Central India, where cotton improvement was the main activity of the Station. Compost-making for soil improvement was extensively studied and later became known as the Indore method. Sir Albert lectured and wrote extensively to advocate the making and use of composts for maintaining soil fertility. He was bitterly opposed to the use of mineral fertilizers, believing that their use was the cause of insects and pests, low nutritional value of the plants grown with fertilizers, etc. He and his disciples completely disregarded scientifically proven findings to further a crusade based on subjective

rather than objective reasoning. An American writer of this school was complimented by Sir Albert for writing audaciously! Not much else can be said in favor of much of the propaganda published by the group.

The book under review is also from Britain, written clearly and simply, though by a chemist. It is a presentation of contemporary knowledge and opinions about fertilizers, manures, and soil fertility. The style is refreshing. The author first presents the case for fertilizers, showing what they can and have done for modern agriculture, and how we could not produce needed crops without their use. Then, when considering the case against fertilizers, he points out that organic matter or humus in the soil is essential for maintaining fertility and satisfactory soil conditions. Even a brief consideration of the facts and arguments presented makes it clear that Sir Albert and his school have not dealt honestly with well established scientific facts. This is a book which can read with profit by all amateur gardeners.

ROBERT L. PENDLETON

MOTHER EARTH. *Being Letters on Soil Addressed to Sir R. George Stapledon.*

By Gilbert Wooding Robinson. Thomas Murby and Company, London. 9s. 6d. viii + 201 pp. + 1 plate + 2 maps; text ill. [1937] 1947.

It is indeed a pleasure to welcome this new edition of so delightfully written and withal so informative a book. The ease and pleasure of reading is enhanced by the essays being cast in the form of "Letters on Soil" which are addressed to a well-known pasture specialist. These essays are authoritative, for the author is one of the most competent soil scientists in the British Empire. This is a "book in which the essential knowledge about soils is presented in clear perspective; a book that will give workers in other fields, geologists, geographers, ecologists, agronomists, and Directors of Plant Breeding Stations, all they need to know for the benefit of their own studies." But the book should also interest the general reader, perhaps even the farmer and landowner, in the story of the soil. The author has not attempted to write a concise manual of soil improvement. Rather, it is a series of essays on the soil viewed from a philosophical standpoint, since this is believed to be the only approach which gives any hope of real progress. On the other hand, the vigorous propaganda which has recently been directed against artificial fertilizers, particularly in Britain, has led to a strongly worded postscript to one of the Letters, which reads in part as follows: "It is asserted with almost mystical fervor that [artificial fertilizers] affect adversely both soils and crops, and that foods produced by their aid are injurious to animal and human health. Such ideas make a natural appeal to the credulous, but actually the evidence adduced will not bear examination."

ROBERT L. PENDLETON

WING TO WING: *Bird Watching Adventures in Five Countries.*

By E. H. Ware; illustrated by Roland Green. Harper & Brothers, New York and London. $2.75. 159 pp. + 16 plates; text ill. 1946.

When the author enlisted in the RAF at the beginning of the last war, he resigned himself to the belief that his bird watching activities would be curtailed for the duration. Much to his surprise and greatly to his delight, however, he discovered not only that there was opportunity to carry on his hobby between stretches of duty, but also that his new career and its attendant travels enabled him to visit foreign lands and to study strange birds. First stationed in England, in Essex, the author observed several birds he had not seen before around his home in Devon. This stay was interspersed with weekend trips to neighboring areas and a seven days' leave to the Scottish Highlands. Then came overseas duty to Algiers, Tunisia, and finally Corsica.

In among the bird notes are descriptions of army life, including the humorous and the monotonous. It is evident that boredom was not in the author's repertory; for so long as he had his field glasses he could contentedly pass away any part of the day. Unfortunately, during his five years' hitch he never encountered another bird student who could share his enthusiasm. Those who like to read about birds and who enjoy searching for and finding new species for their life list will derive much vicarious pleasure from this book. It is illustrated with photographs by the author and sketches by Roland Green.

HENRI C. SEIBERT

AN ANNUAL CYCLE OF THE PLANKTON AND CHEMISTRY OF FOUR AQUATIC HABITATS IN NORTHERN FLORIDA. *University of Florida Studies, Biological Science Series, Volume IV, Number 3.*

By E. Lowe Pierce. University of Florida Press, Gainesville. $1.60 (paper). xii + 67 pp. + 2 charts; text ill. 1947.

As compared with more northern areas, the inland waters of Florida are more uniform, especially in their temperature and dissolved oxygen content. The relation between these factors is inverse. The entomostraca population showed no pronounced fluctuation, but seasonal pulses of rotifers and definite phytoplankton pulses occurred.

EVOLUTION

OUR FLOWERING WORLD.

By Rutherford Platt. Dodd, Mead and Company, New York. $6.00. viii + 278 pp. + 8 plates; text ill. 1947.

The evolution of the flowering plants presents, even with the many gaps that still exist, one of the most fascinating stories of all times, yet to the layman it is a closed and unintelligible one. Hidden in forbidding technical volumes, and clothed in botanical jargon, it has lacked a champion who could disclose it in its proper setting for everyone to view. Rutherford Platt has taken this task upon himself, and to state that he has succeeded admirably is to make an obvious understatement. With simple words and a series of remarkable black-and-white and colored photographs, Platt carries the reader through the ages, viewing the varied scenery, and spying on the natural processes that are slowly but inevitably forcing change upon the earth and its floral inhabitants. One needs no training in the botanical sciences to appreciate that time has no meaning, or that adaptive perfection is the only goal whose attainment is a necessary prerequisite for continued existence. In his handling of the floral magnificence of the Carboniferous, and of the evolution of the angiosperm flower and herb, Platt has given to botany a type of literary exposition which the textbook writers would do well to imitate.

It is only when the author begins to interpret evolutionary changes that he falls into serious error. The theory of Gondwanaland and the meaning of the distribution of the fossil *Glossopteris* are stated with a finality that would most certainly be disputed by geologists and botanists alike. His teleological and Lamarckian reasoning likewise carries him far astray. He seeks a "creative spirit" to account for the changes in plants, and this he finds in climatic pressures when he points out that "important changes in plants result from changes in climate" and "when pressures come along, protoplasm immediately responds." He again elaborates on this theme by stating: "From the first alga to the cattleya orchid, from the dawn-seed fern to the flowering dogwood, the simple laws of life and growth have never been violated. . . .The sensitive controls of this mighty mechanism are temperature and moisture. Climate was the architect of glossopteris just as it is of trailing arbutus and blueberries." Genes are mentioned once in the text. Platt similarly misinterprets the Darwinian theory of evolution, giving to it a Lamarckian twist. "According to this [Darwin's theory], the living cell takes all sorts of chemical and structural steps, and that which brings the organism into the best balance for living is retained and becomes an improvement that is incorporated into the chromosomes and passed along to future generations." This is obviously putting the cart before the horse, if we are to accept the experimental data which have flowed from the biological laboratories since the time of Darwin.

Despite these errors of interpretation, this is the kind of book which brings to botany a fresh and uncluttered point of view. No one who reads the volume and again views a ginkgo will forget that "it is a transition, a moment in evolution caught and fixed in mid-course." Or that plant evolution is a timeless "assembly line" where "accessories are added, or parts are subtracted." We can accept or reject, as our background and training permits, the teleological interpretation of the author as to the "whys and wherefores" of organic existence.

C. P. SWANSON

GENETICS AND CYTOLOGY

INTRODUCTION TO GENETICS AND CYTOGENETICS.

By Herbert Parkes Riley. John Wiley and Sons, New York; Chapman and Hall, London. $5.00. xii + 596 pp.; ill. 1948.

As presented to undergraduate students, genetics may be introduced as an abstract science obeying the laws of probability, or as one aspect of a two-sided phenomenon in which the abstract considerations have been shown to possess a physical counterpart in the behavior and structure of the chromosomes and the cell. Riley, being a cytologist, has chosen the latter method, and in his recent book has made an attempt to weld the abstract and physical aspects of the problem into an organic whole by an emphasis upon the chromosomal mechanism of inheritance. The desirability of this approach is obvious, if not necessary, for the marriage of genetics and cytology has been a fertile one, even though one not always characterized by connubial bliss. The presentation of material in Riley's book is not a novel one, but the comprehensive treatment of cytogenetic data has been a long-felt need. That the task is formidable few will deny; that this volume meets the need, however, is rather questionable.

As a textbook, it must be judged by two criteria: the contents, and their presentation. As to contents, Riley has succeeded in incorporating a tremendous amount of factual material. A more judicious selection of material for illustrative purposes would have greatly improved the volume; certainly much that is desirable in the cytogenetic picture has been omitted. The gene-deficiency relationships in chromosome 9 in maize and in the Notch series in *Drosophila*, the considerable research on chromosome chemistry, the genetic studies on microorganisms, and the intrachromosomal relationships of crossing over, for example, are scarcely mentioned, if at all. The first five chapters could well have been compressed or incorporated into other chapters. Since genetics is generally presented as a semester course, it is doubtful whether all of the material can be

covered, and the student is rarely able to make a proper selection when given a choice.

As to presentation, the book has been divided into four sections: 1) an introductory survey of five chapters; 2) eight chapters devoted to gene transmission; 3) ten, to the nature and physiology of the gene; and 4) seven, to chromosomal aberrations and evolutionary processes. These are broad divisions with considerable overlap, and there are some obvious, though not serious, inconsistencies. While the order of presentation will depend upon the individual author, and Riley's sequence is a reasonable one, a criticism can be leveled at the manner of presentation. Lacking in clarity and integration, the disjointed and almost reportorial treatment will cause the student trouble in relating the fundamentals of genetics to the more technical aspects of cytogenetics. One reads with the feeling that Riley simply abstracted those articles which he felt to be important, conveniently grouped them into chapters, but forgot to knit them into a whole fabric. The author likewise has the mistaken notion, thus ignoring a vast amount of data, that because the Darlingtonian hypotheses of chromosome mechanics are beautifully logical they are therefore scientifically correct. Not only has the heart of the cytogenetical subject been given a biased presentation, but the student is given a false sense of scientific security which will not stand him in good stead for advanced work. The student who ingests this mass will find it exceedingly difficult of digestion.

The over-all result is a volume that, while urgently needed, is still neither a good elementary textbook nor a usable reference. The subject matter still awaits an interpreter.

C. P. SWANSON

HOW LIFE IS HANDED ON.

By Cyril Bibby. Emerson Books, New York. $2.00. 159 pp.; ill. 1947.

There is a great need for a book just like this. Teachers and parents still shy away from sex instruction and leave it to the children to pick it up from one another. How much better this forthright discussion in language a 10-year-old can understand! Cyril Bibby is an Englishman, a fact worth note—one must still go abroad to find a qualified teacher with sufficient courage and enterprise to undertake sex education at the really appropriate age level.

The discussion itself is biological in tone and accurate as to fact. The drawings are clear and graphic, and every question about reproduction likely to occur to the mind of a 10-year-old seems to have been anticipated. There is no dodging of legitimate curiosity—no beating around the bush for bees and butterflies. The story of reproduction is handled in a comparative way, with main emphasis on mammals, and especially the human species. The role of genes and chromosomes is clearly explained in a very simple manner. The chapter on The Declining Birth Rate is a model for discussions of population problems and eugenics—and unlike many American editions of foreign books, has really been rewritten for Americans. Appendixes contain Questions and Answers, well-chosen Things to Do, a list of Other Books to Read and Some Films to See, and a glossary. The solitary imperfection noticed in an otherwise flawless book was the overemphatic nature of the negative answer given to the question: "Can you inherit tuberculosis?" All in all, the book fully deserves a Gold Seal of Merit for biological books written for the younger generation.

BENTLEY GLASS

HOW TO BREED DOGS. *A Popular Exposition of the Scientific Principles Underlying Reproduction and Heredity in Dogs, with Special Reference to their Practical Application. Revised Edition.*

By Leon F. Whitney. Orange Judd Publishing Company, New York. $4.50. xviii + 418 pp.; ill. 1947.

This is a popular exposition of the scientific principles of dog breeding. It is written and illustrated in a style which should make it easily understood by the layman. Accuracy seems reasonably high, but in some cases there is a tendency to oversimplify things. For example, cell division is much more complicated than one might be led to believe by reading the second chapter of the book. In a later chapter, on twins and litters, a method of obtaining greater size in dogs is given. This consists of producing two inbred strains and then crossing them. This method would not necessarily give dogs that were larger than the original stock, and the difficulty of producing two highly inbred lines is treated lightly. In the entire book comparatively little emphasis is placed on selection.

The book is divided into four parts and contains forty-three chapters. Part One is mainly on physiology and practical problems of reproduction. A brief anatomical description of the male and female reproductive organs is given, and the mating cycle of the female is well described. The most opportune time to mate is about the fourteenth day after the first signs of bleeding. How to detect pregnancy by palpation at three weeks is described. The sex hormones are treated briefly; however, the use of progesterone in postponing the mating cycle is mentioned. The most extreme case of prolificacy mentioned is that of a bitch which whelped 129 puppies in her first eight litters.

The second part of the book starts with a simple discussion of the principles of heredity and Mendelism. It is emphasized that germ plasm changes by mutation

and not by the inheritance of acquired characters, maternal impressions, birth marks, or by telegony. The inclusion of such a discussion for the layman seems appropriate. Sex determination is described briefly. In connection with quantitative methods such things as progeny tests and pedigree records are mentioned, but little is done toward explaining and applying them.

Part Three is much the largest part of the book. It treats in some detail the inheritance of coat color, coat characteristics, eye color, and tail characteristics. Mental aptitudes, body form, and disease resistance are discussed briefly. A summary of the color genes is included in the chapter on the knowledge of dog genetics up to 1937. Under mental aptitudes, the gene for open trailing is stated to be dominant to that for mute trailing. Many other interesting cases are reported. Whitney is of the opinion that one selects against intelligence when one disposes of the fence climbers, etc. In his kennels, the English type bloodhound lost every pup to Carre distemper, whereas the American bloodhounds lost only fifty per cent. Certain diseases seem to be more prevalent in certain breeds, as scotch itch in Scotch Terriers.

The last part of the book consists of pertinent advice to persons who may wish to start the dog hobby. If one does not have ample means it would be wise, the author says, to buy a female which is a poor specimen from a great family and to breed her to a male who has produced uniformly good offspring. He bases this advice on the fact that exceptionally good individuals seldom produce offspring as good as themselves and seldom do poor individuals produce offspring as poor as themselves.

The dog breeder will find this book to hold a wealth of information, presented in a form very easy to understand. The geneticist will find it a good source of dog genetics, although he may wish also to consult the original papers.

ROBERT W. TOUCHBERRY

GENERAL AND SYSTEMATIC BOTANY

THE LIFE CYCLE OF A PLANT. *A Work Book in Botany.*

By F. Whitwam Jones. J. M. Dent and Sons, London. 1s. 8d. (paper). 64 pp.; ill. 1946.

This is a unique laboratory manual in that most of the illustrations to be labelled are natural photographs rather than the diagrammatic line drawings which so many students find it difficult to understand. Many of the reproductions are too poor to be useful, however. While well prepared, and carefully written, its limited scope tends to restrict the usefulness of the manual in a general science program.

C. P. SWANSON

LABORATORY MANUAL OF ELEMENTARY BOTANY. *Second Edition. McGraw-Hill Publications in the Botanical Sciences.*

By Arthur W. Haupt. McGraw-Hill Book Company, New York and London. $1.25. x + 79 pp. 1946.

The second edition of this manual is designed to meet the changes incorporated into the second edition of Haupt's introductory text. It is adaptable as a one- or two-semester laboratory manual, and it appears to satisfy the requirements of most elementary botany exercises without keeping the instruction on too rigid a basis.

C. P. SWANSON

NORTH AMERICAN SPECIES OF MYCENA. *University of Michigan Studies, Scientific Series, Volume XVII.*

By Alexander H. Smith. University of Michigan Press, Ann Arbor; Geoffrey Cumberlege, Oxford University Press, London. $6.00. xviii + 521 pp. + 99 plates; text ill. 1947.

The book defines the genus *Mycena* in the widest sense, the author including even more groups of agarics in it than Fries and Saccardo did. A short history of past research on *Mycena* in North America, an interesting discussion of the diagnostic characters, and a review of the accepted classification (the author divides *Mycena* into 17 sections and a number of subsections and *stirpes* which are all grouped within the four main subgenera: *Pseudomycena*, *Eumycena*, *Glutinipes* and *Mycenella*) form the chapters that make up the introduction. The main part of the work consists in a complete taxonomic treatment of the temperate species, including some subtropical ones. The majority of the tropical and subtropical species are treated separately, since the author's contribution here consists mainly in a critical study of W. A. Murrill's type specimens. The text is accompanied by numerous microscopical drawings (56 figures) and original photographs of the fresh fruiting bodies (on 98 plates). There are 232 complete descriptions (including data on the iodine reactions of the spores and tissue, in addition to all macro- and microscopical details), and the synonymy is given with care and responsibility.

At the present stage of our knowledge of the Basidiomycetes, it is essential that taxonomic monographs based on a broad approach (not excluding cytology, anatomy, chemical characters, and ecology) should continue to be published. This statement, self-evident as it may appear, is not one taken for granted by all botanists, and it is difficult to find a publisher for the larger monographs. Under these circumstances, mycologists will gladly join the author in expressing his appreciation to the University of Michigan Press for accepting the manuscript. It is a regrettable fact that in the taxonomic field many papers with a narrow,

schematic concept of systematics, full of deficiencies, and with few actual contributions to our knowledge have found their way into the literature, and it has become very difficult for the biologist who is looking for the best information currently available to differentiate between really modern and merely recent monographs. It is a pleasure to acknowledge that A. H. Smith's *Mycena* book belongs in the category of important contributions, with an immense number of new descriptive data, and a key that will satisfy those who have the experience and discrimination to use scientific keys to the Basidiomycetes.

It has been said, in a review of an earlier *Mycena* monograph by the French mycologist R. Kühner, that it is becoming increasingly more difficult, and even impossible, for a non-specialist to use modern taxonomic papers on agarics because of the new anatomical and chemical characters introduced by Kühner. Maybe with this statement in mind, A. H. Smith has endeavored to exclude the Melzer reaction both from keys and from his main classification. It is debatable whether or not this procedure should be considered an improvement. The reviewer is inclined to think that it is not. There is also the perpetual matter of nomenclature. The reviewer would have preferred some new names instead of older European names with uncertain interpretation. But the author has conscientiously followed the International Rules of Nomenclature, which will make the names he has adopted more stable than those adopted in other papers—altogether too numerous—where the authors seem to make their own rules.

ROLF SINGER

THE FERNS OF NEW JERSEY *Including the Fern Allies. By M. A. Chrysler and J. L. Edwards. Rutgers University Press, New Brunswick.* $4.00. x + 201 pp.; text ill. 1947.

An excellent descriptive manual of the ferns and fern allies of New Jersey, finely printed and illustrated. There are introductory chapters on the structure and life history of a typical fern plant, on distributional phenomena, classification and nomenclature, and on the problem of fern hybrids. The book is amply supplied with keys and photographs by which most of the species can be identified. Spot maps of known distribution in the state are given for nearly all of them. The authors have been conservative in their treatment of species complexes, and have included only enough synonymy to make the book referable to the standard manuals. The descriptions and accompanying notes are brief, but are done in such a manner as to make the book usable for student and layman alike. The catalogue and its attendant notes appear to have been based upon ample collections and authoritative determinations. Glossary, references, and an index close the book.

H. M. RAUP

FLORA OF DELAWARE AND THE EASTERN SHORE. *An Annotated List of the Ferns and Flowering Plants of the Peninsula of Delaware, Maryland and Virginia. By Robert R. Tatnall. The Society of Natural History of Delaware, Wilmington.* $3.50. xxvi + 313 pp. + 9 plates; text ill. 1946.

The Peninsula "Delmarva," comprising the State of Delaware, nine counties of Maryland, and two of Virginia, and forming the eastern shore line of the Chesapeake Bay, is, by virtue of its geologic structure, an area rich in botanical diversity. Made up of Coastal Plain and Piedmont Plateau, the former geologically young and the latter very old, the Peninsula has two very characteristic flora, while sharing in common a more mobile and less ecologically restricted flora. It is likewise an area where many plants end their northern or southern distribution. Tatnall, direct descendant of Edward Tatnall, whose Tatnall Catalogue of 1860 was one of the earliest botanical publications concerned with this region, has presented in this volume an annotated list of the ferns and flowering plants of the "Delmarva" peninsula, with the listing sequences generally constructed on the plan of Gray's *Manual*. Each species is given its scientific name according to the International Rules, a common name, origin if introduced, ecological habitat, and approximate flowering time. It should be a welcome book to students of our eastern flora.

C. P. SWANSON

À LA DÉCOUVERTE DES ORCHIDÉES DE FRANCE. *Les Livres de Nature. By J. Poucel; preface by Jean Giono. Editions Stock, Paris.* 30 fr. (paper). 222 pp.; ill. 1942.

This little book, one of a popular series (Les Livres de Nature) is divided into two parts. Part I, "What Orchids Tell," has such subtitles as The Mountain in Bloom, Aerial Cousins of the Tropics, the Strange Love-life of Orchids, the Fungus Eaters or the Mysteries of Germination, Underground Existences, Conjurers and Magicians, Chance and the Orchid-fancier (by Jacques Delamain), Where the Orchids Lodge and in what Companionship (by P. LeBrun). This section attempts in a very popular way to indicate the scope of the Orchid Family, i.e., their variety and range, together with a comparison of the more showy tropical species with native species, a discounting of the generally credited theory of floral modifications for purposes of attracting

the fertilizing insects, the various methods of pollination based on the work of Darwin, the phenomena of mycorrhizal penetration into orchid roots as noted by Bernard, the various root structures, the supposed magical properties of orchids, the discovery of natural hybrids, the writer's experiences with other orchid hunters, and the soil preferences of different species.

Part II, entitled "How I Gathered Our 76 Indigenous Species," has the following sections: On the Chase—the Pursuit and Capture of Orchids, including a botanical apprenticeship with the common species; Herborizing and the Rarer Species; and Life in the Open and the Observing of Nature. After rationalizing orchid-hunting and explaining its advantages, the author gives his own experiences while collecting both the common and rare species.

At the end of the book there is a List of the Orchids of France (occupying 6 pages) giving, in tabular form, each species name with its translated meaning, preferred habitat, time of blooming (month), and relative abundance or rarity. Some of the figures (line drawings) are clear and definite, but most of the photographs are poorly reproduced and very faint.

Altogether this little book is a readable and entertaining introduction to the subject of the native orchids of France, and contains much valuable information, especially in the tabular list at the end.

CHARLES SCHWEINFURTH

A TAXONOMIC STUDY ON THE GRASSES OF PENNSYLVANIA. *The American Midland Naturalist, Volume 38, Number 3.*

By Richard Walter Pohl. The University Press, Notre Dame, Ind. 90 cents (paper). Pp. 513–604; ill. 1947.

There are 77 genera, 233 species, and 40 varieties and named forms of grasses recorded from Pennsylvania. The diversity of the grass flora is shown by the fact that, except for two small tribes (one of a single introduced species), all tribes known from the United States are represented. Two of the climatic zones of Livingston, medium and cool, occur in the state. The grasses of Pennsylvania are first grouped by range and habitat, those of wide distribution in the state, those of northern range, of southern range, of Atlantic Coastal Plain, of river valleys, of aquatic or wet ground, and of serpentine barrens and limestone soils. Introduced species, 73 in all, including 8 from other states, mostly western, are listed. Ballast waifs and the like, collected but once or twice and apparently extinct within the state, are listed under Excluded Species. Most of the work is devoted to the Systematic Catalogue of the Grasses of Pennsylvania. This is provided with carefully worked-out keys to tribes, genera, species, varieties, and forms. References to recent revisions and articles are given under the genera. The species and varieties are not described, the ample keys serving to identify them, but detailed habitats and localities are given, and specimens are cited for critical species. What makes the catalogue of especial value is the fact that all records are based on specimens examined by the author in the herbarium of the University of Pennsylvania and in other large herbaria, and not on unverified reports.

AGNES CHASE

THE REDWOODS OF COAST AND SIERRA. *Fourth Edition. By James Clifford Shirley. University of California Press, Berkeley and Los Angeles.* $2.00 (cloth); $1.00 (paper). 84 pp. + 1 plate; text ill. 1947.

This little book was first published in 1936 as a popular account of the redwood forests of California. The current edition is the fourth. It is informative, well written, and well illustrated with full-page photographs. There are maps of the modern and fossil distributions of the redwoods. The book contains chapters on the discovery of the redwoods by Europeans, on their distribution, vitality, manner of reproduction, size, age, and uses. Finally, there is an eloquent plea for the preservation of stands that will adequately represent the species. A partial bibliography is included for those who wish to delve more deeply in the lore of the "Big Trees."

H. M. RAUP

THE CULTIVATED SPECIES OF PRIMULA. *By Walter C. Blasdale. University of California Press, Berkeley and Los Angeles.* $7.50. xii + 284 pp.; ill. 1948.

This work supplies still another authoritative monograph on genera of horticultural interest—this time on *Primula*. The first chapter is concerned with a definition of terms, the history of the genus and its classification. Another chapter deals with biological characteristics such as the life cycle, teratological peculiarities, dimorphism, hybridization, geographical distribution, and phylogeny. Under Horticultural Requirements and Methods, the author discusses propagation, soil and moisture requirements, diseases and pests. The next fifteen chapters are devoted to a detailed account of the 34 sections of the genus *Primula*, with observations concerning all the species of known or potential value for cultivation. Hints are given regarding the successful cultivation of various species, based on the author's own experience. A final chapter on the cultivation of Primulas in the United States emphasizes the neglect of the group in this country, save for the Pacific

Northwest. The book is illustrated with figures, a map, and 88 photographs nearly all taken by the author. A bibliography is appended.

ALBERT F. HILL

BULBS FOR BEAUTY.

By Charles H. Mueller; drawings by Else Bostelmann. M. Barrows and Company, New York. $3.50. 296 pp. + 16 plates; text ill. 1947.

Bulbs for Beauty was written by its author, a professional grower and dealer in bulbs, with a three-fold purpose: (1) to attempt to answer the many questions which daily arise to vex the amateur by providing useful information; (2) to enable the gardener to obtain better flowering results by discussing proper culture methods; and (3) to suggest ways for obtaining greater enjoyment from bulbs by furnishing descriptions of varieties and methods of planting. Throughout the the work, ease of culture and market availability are cardinal principles.

The first eight chapters deal with matters of general interest, as evidenced by the titles: This World of Bulbs; Matters Botanical; Giving New Bulbs a Start; Spring Care That Looks Ahead; The Question—To Lift or To Leave; How Deep to Plant; The Weather Plays a Part; Bulb Enemies Outwitted. Considerable space is devoted to specific bulbs—to tulips in particular. In addition to general information, some 170 varieties are characterized briefly. Daffodils and narcissus, hyacinths, lilies, and iris each have one or more chapters devoted to them. Twenty-five other bulbs of lesser importance are discussed in the chapters entitled Early and Irrepressible, and Satellites for Spring Stars. Other chapters are concerned with such matters as Spring Planting for Summer Bloom (chiefly dahlias and cannas); More Color in Summer (featuring 13 different species); Hardy Bulbs with Autumn Flowers (colchicum and autumn crocuses); Easy Indoor Flowering; Woodland Planting; and Bulbs for Rock Gardens and White Gardens. The last two chapters are supplemented by lists of hardy species.

The book concludes with a month by month reminder, a glossary and an index. It is illustrated with fifteen fine photographs and numerous line drawings by Else Bostelmann.

ALBERT F. HILL

ROSES OF THE WORLD IN COLOR. *Third Edition.*

By J. Horace McFarland. Houghton Mifflin Company, Boston. $5.00. xxiv + 296 pp.; ill. 1947.

No flower is more universally loved than the rose, and probably no one person is better qualified to discuss technically and appreciatively the merits of roses and rose culture than is J. Horace McFarland. In the third edition of this book the more recent introductions, arranged alphabetically, are included and fully described, together with information on their introduction, thus swelling the total list of varieties and species described to nearly six hundred. The number of colored illustrations numbers well over one hundred, giving the rose enthusiast a bewildering array of colors, sizes, and shapes from which to choose. However, this is a book for a select group of gardeners; its usefulness is limited, and could well have been extended by the inclusion of selected lists of varieties for various cultural and climatic conditions. The uninitiated grower will have difficulty in choosing his roses from the colored plates, all of which are lavishly beautiful; for the text, while interesting, is not informative.

C. P. SWANSON

BEGONIAS FOR AMERICAN HOMES AND GARDENS.

By Helen K. Krauss; Line Drawings by Marjorie-Ann Tobin, Begonia Charts by Alpha H. Gere. The Macmillan Company, New York. $4.00. xxvi + 228 pp. + 24 plates; text ill. 1947.

Probably no genus of ornamental plants equals the tremendous diversity of leaf structure and plant habit exhibited by the begonias. The number of cultivated varieties seems endless. Helen Krauss considers the genus to be made up of over 1,200 good species, but the ease with which these may be hybridized leads one to suspect that a horticultural species and a taxonomic species are not one and the same. Be that as it may, the begonias have become one of our favorite household plants, and the author has performed a Herculean task in attempting to bring order out of the chaos of synonomy in begonia nomenclature. To what extent she has succeeded can only be determined by a specialist. She has, however, presented a useful series of genealogical charts that trace the history of the many varieties; and these, together with a brief sketch of the discovery and introduction of the American and Asiatic species, provide the flower lover with a most interesting bit of botanical lore. Each of the major types of begonias has a chapter devoted to it. An excellent chapter on methods of culture and propagation, followed by a reference list, makes this a commendable volume for both the amateur and the professional gardener, even though its value to the systematist is questionable.

C. P. SWANSON

OUR OLD-FASHIONED FLOWERS.

By Olive Percival. Pasadena Humane Society, Pasadena; The Ward Ritchie Press, Los Angeles. $5.00. viii + 245 pp.; ill. 1947.

Attractively bound, and prefaced by a syrupy, sentimental discourse on flower-name history, Olive Percival's volume is a compilation of "Old-fashioned Flowers—a Latin-English list," "Old-fashioned roses—an English-Latin list," and "Pot herbs, sallet herbs, strewing herbs, and simples—a Latin-English list," each alphabetically arranged. These are followed by an excellent bibliography of source references, and two English-Latin indices of flowers and herbs, alphabetically listed according to English name. The lists make fascinating reading, and it is to be regretted that many of the names have disappeared with the passage of time. Such names as "Meet-her-in-the-entry-kiss-her-in-the-buttery" (*Viola tricolor*), "Devil's Guts" (*Cuscuta*), "Maiden's Ruin" (*Artemisia abrotanum*), and "Sorcerer's Violets" (*Vinca*) might well have been preserved. Certainly our forefathers were not lacking in imagination.

C. P. SWANSON

TREES AND TOADSTOOLS.

By M. C. Rayner. Rodale Press, Emmaus, Pennsylvania. $2.50. x + 91 pp. + 18 plates; text ill. 1947.

This is an American printing, unchanged, of the authoritative but non-technical little book reviewed in Q. R. B. 21: 84, 1946. It is a very worth-while addition to any biological library, institutional or personal.

ECONOMIC BOTANY

HORMONES AND HORTICULTURE. *The Use of Special Chemicals in the Control of Plant Growth.*

By George S. Avery, Jr. and Elizabeth Bindloss Johnson; with the collaboration of Ruth M. Addoms and Betty F. Thomson. McGraw-Hill Book Company, New York and London. $4.50. xii + 326 pp.; ill. 1947.

Whenever a new field of investigation claims the attention of scientists it is often many years before the results of their investigations find their way into textbooks. Only the specialist who has access to the widely scattered information on the subject can accurately evaluate the results. *Hormones and Horticulture* thus renders a great service to botanists and horticulturists by bringing together the important data regarding the use of chemicals involving hormones in the control of plant growth, an advance which the authors regard as a "real chemical revolution in agricultural practice." Throughout the book the word "hormone" is used as synonymous with "auxin" or "growth substance."

The main facts of historical importance in the field are outlined, and the results obtained by the many workers are recorded. Specific directions are given for applying the chemicals, their usefulness in horticultural practice is evaluated, and the trends in the field are pointed out. The senior author, a leader in hormone research, has had the critical advice of many horticultural specialists in the preparation of the book, the scope of which is best indicated by the titles of the chapters: Hormones and the Rooting of Cuttings; Blossom-thinning Sprays in the Control of Fruit Production; Hormone Control of the Preharvest Drop of Fruits; Hormones as Aids to Fruit Set and to Seedless Fruit Production; Hormone Treatment of Seeds; Hormones and Vitamins in Relation to Miscellaneous Growth Phenomena; Hormones and Weed Control; Breaking Dormancy with Chemicals; Hormones in Prolonging or Inducing Dormancy; Chemical Production of New Varieties [dealing with the use of colchicine and other chemicals in the production of polyploidy]. Extensive bibliographic references and a subject index are included.

ALBERT F. HILL

GROWTH REGULATORS *for Garden, Field, and Orchard. By John W. Mitchell and Paul C. Marth. The University of Chicago Press, Chicago.* $2.50. viii + 129 pp. + 1 plate; text ill. 1947.

The increasing practical importance of the natural and synthetic plant growth regulators makes it imperative that simplified instructions be issued for the application of these chemicals, if full use is to be made of them in the many and diverse fields of agriculture. Improperly handled, these chemicals are apt to be dangerous tools in the hands of the uninformed, and since the amounts required are so minute as compared to, say, spray or fertilizer applications, the damage to plants by uncontrolled dosages can be extensive. Mitchell and Marth, two of the investigators who have been responsible for furthering this field of research, have presented easily-followed methods for the use of plant growth regulators as weed-killers, rooting compounds, fruit-drop preventatives, yield and quality promoters, and inducers of other plant responses. The value of the synthetic growth regulators to the commercial grower is so great that no producer of crops should be without knowledge of the methods of application contained within this slender volume. The home owner, too, will find that his tasks will be enormously simplified by a judicious use of these truly remarkable compounds.

C. P. SWANSON

CROISSANCE DES VEGETAUX CULTIVÉS. *Principes d'Agronomie—Tome 11. Third edition.*

By Albert Demolon. Dunod, Paris. 580 fr. (paper). xiv + 367 pp. + 2 plates; ill. 1946.

This book, the second volume of *The Principles of Agronomy*, is in reality a textbook of plant physiology with agricultural applications. Published first in 1934, this new edition brings the subject matter up to date, with the inclusion of much new material. The first part of the work is devoted to the physical factors which influence growth, i.e., light, temperature, etc. The second section, concerned with chemical factors, has chapters on the atmosphere and plants; the root system; water; mineral nutrients; nitrogen; phosphorus and sulphur; potassium; calcium, magnesium, and other mineral elements; and the phenomenon of toxicity in agriculture. A third section deals with biological factors, chiefly microorganisms; and the fourth part discusses growth and yield under such headings as the laws governing plant growth, fertilizers, the quality of the harvest, experiments in agronomy, and the analysis of the plants.

ALBERT F. HILL

SEMENCES ET PREMIÈRES PHASES DU DÉVELOPPEMENT DES PLANTES. *Caractéristiques de la Provenance des Céréales. Extrait des Annales de Phytogénétique (Tome VII, numéro spécial—1941).*

By Louis François. Imprimerie Nationale, Paris. 55 fr. (paper). 90 pp.; ill. 1941.

Weeds are of so much economic importance to the farmer and gardener that any addition to the literature of the subject is welcome, particularly when it pertains to the identification of the seeds or seedling stages of weeds. In the present paper, which follows the style of the author's previous works on the same general subject, two different types of weed seeds are considered: (1) the seeds of plants which occur with cereals, and (2) the seeds of species which are found with forage legumes and grasses. In the latter instance, one section is devoted to the weeds whose seeds are usually found mixed with those of the cultivated plant; and a second section is concerned with species which play an important role during the actual cultivation of the crop.

The most frequently encountered species in 25 different families are discussed. Full descriptions of the seed (or fruit) and of the seedlings are given, often with keys. Where essential, the characteristics of the mature plant are also given. The scientific and common names are furnished, along with data regarding the geographic distribution (often with maps). Perhaps the most valuable feature of the paper is the large number of excellent photographs of the individual seeds and fruits. The reproductions of the seedlings are not as well done.

ALBERT F. HILL

ARMCHAIR GARDENING. *Some of the Spirit, Philosophy, and Psychology of the Art of Gardening.*

By Thomas Hubbard McHatton. The University of Georgia Press, Athens. $2.50. viii + 130 pp. 1947.

Garden books are so numerous and so varied that the everyday lover of plants is likely to become bewildered and perhaps a little weary of the mass of data which is to be found on every side, ready for his perusal. Most of the available books follow a regular pattern and are either pictorial (and often expensive) or cyclopedic (and by the same token a bit boring). What a relief it is to find a book written in a philosophical vein and emphasizing the psychology of the art of gardening, with stress laid on how to appreciate a garden through the utilization of all the senses, rather than the more prosaic business of how to grow plants.

As the author, who is Professor of Horticulture at the University of Georgia, says: "It is through the reactions of the human being to things that can be seen and heard, smelled, tasted, and touched, that he finds the enjoyment and pleasure, or the distaste, that may be had from the work of a garden artist."

McHatton's thesis is that gardening is as much one of the fine arts as sculpture, painting, architecture, or music, and equally appealing to the senses. With amazing clarity and in non-technical terms he shows what part sight, hearing, smell, touch, and taste each plays in the appreciation of a garden. He points out that the good gardener must have a real interest in the plants themselves.

The final chapters are more historical in nature and deal with the genesis of American gardening, America's role in gardening, and "Garden Treks"—tours to famous gardens.

ALBERT F. HILL

NEW RICHES FROM THE SOIL. *The Progress of Chemurgy.*

By Wheeler McMillen. D. Van Nostrand Company, New York. $3.50. xii + 397 pp. 1946.

The story of the industrial utilization of plant raw materials is always fascinating. Chemurgical research in recent years has found many new uses for farm crops and farm wastes, and has developed new crops for man's greater benefit—all pointing to a new industrial and economic security with an underlying philosophy of creating wealth and opportunity for all.

Wheeler McMillen, the author of this volume, is one of the world's most famous agricultural editors and, as president of the National Farm Chemurgic Council, Inc., has seen his dream of bringing agriculture, industry and science into countless profitable relationships come true. The book attempts: (1) to report practical chemurgic developments; (2) to outline the history of the

chemurgic concept and of its organization; and (3) to state the significance and implications of the underlying philosophy.

The subject matter may best be indicated by a listing of the table of contents: The Background; How Chemurgy Started; Chemurgy Is Organized; The Cigarette Paper Story; Corn, a Crop with New Ideas; Corncobs and Oat Hulls; Soybeans, a New Crop that Has Arrived; New Crops for Wheat and Cotton Lands; A Farmer Works at Chemurgy [the growing of cotton to precise industrial specifications]; Chemurgy in the Everglades [chiefly lemongrass oil and sweet potato starch]; Oils from the Sun; Many a Mickle Makes a Muckle [discussions of sage, coriander, castor beans, bamboo, insecticides, guar, milkweed, etc.]; The Empire of Fibers; Wealth from the Woods; Animal Chemurgy; Fruits from New Branches; The Subject of Alcohol; American Farm Rubber [guayule and Russian dandelion]; Government Takes a Hand; Chemurgy Reaches the Grassroots; How the Chemurgic Council Works; What Makes It Pay?; The Economics of Chemurgy; and A Force for Peace.

The book is well written and should prove interesting and enlightening to everyone, whether professional or amateur, who is interested in agriculture, economics, or the general welfare of the nation.

ALBERT F. HILL

DANISH AGRICULTURE: *Its Economic Development. A Description and Economic Analysis Centering on the Free Trade Epoch, 1870–1930.*

By Einar Jensen. J. H. Schultz, Copenhagen. Dan. Kr. 17.—. xvi + 417 pp. + 1 map + 2 charts; text ill. 1937.

This book, as the subtitle implies, is an interpreted economic history and description of Danish agriculture. The early history of Denmark is surveyed in Chapter I. This is followed in subsequent chapters by descriptions of the climate, soil topography, people, institutions, land policies, commercial policies, agricultural practices, and agricultural statistics. Four chapters are devoted to economic phases of Danish agriculture and one to cooperative agricultural organizations. From the system of peasantry common to other European countries, Denmark has evolved a system of prosperous free business farms, with the farmers owning and operating the agencies that process and market their products on a cooperative basis. The grain and sheep farms that prevailed before 1870 were transformed into the more intensive enterprises of dairying, and hog and poultry production. Industries attracted labor from the rural regions. The combined effect was to permit a stable farm population and to avoid the subdivision of farm lands into uneconomic units. Cooperative stores supplied the farmers with most of their needs. Extensive exports of butter, eggs, and bacon facilitated the importation of feed grains.

Acre yields of grain were increased fully 50 per cent between 1875 and 1925 by improved farming methods, including better crop rotations, the use of manures and fertilizers, and the breeding of better varieties. This was accompanied by comparable improvements in livestock production. Mechanization replaced much of the hand labor.

The author has presented a detailed analysis of how the free Danish people were able to develop a high type of agriculture that has stood as a model to other nations for half a century.

JOHN H. MARTIN

NATURE AND PREVENTION OF PLANT DISEASES. *Second Edition. Blakiston Books on Agriculture.*

By K. Starr Chester. The Blakiston Company, Philadelphia and Toronto. $5.00. xii + 525 pp.; text ill. 1947.

In this second edition of the book first published in 1942 (see Q. R. B. 18: 87), the subject matter is rearranged and brought up to date, additional diseases are included, and some 30 illustrations and numerous references have been added. The book, which is designed as a textbook for students taking only a single course in plant pathology, appears to meet these requirements to a marked degree. Although considerable attention is given to general fundamental principles, procedures, and techniques of plant pathology, the book also serves as a handbook for the recognition and control of the more important plant diseases. Obviously this arrangement results in some duplication of subject matter. In addition to parasitic diseases caused by fungi, bacteria, viruses, nematodes, and algae, the author discusses parasitic seed plants, mineral-deficiency symptoms, and diseases due to other unfavorable environmental conditions.

The discussions of specific diseases are grouped according to the causal organism or condition. The well illustrated text is divided into 20 chapters followed by a comprehensive glossary. The normally highly technical subject matter is covered in a simple readable style calculated to maintain the interest of the beginning student in plant pathology. Unfamiliar terms are defined, and structures are illustrated by simple drawings.

The obvious inaccuracies and ambiguities so frequent in the first edition have been corrected. However, a number of inaccuracies appear even in the second edition. For example, Kanred wheat was selected in 1906 from a Russian wheat introduced several years previous to 1906 (p. 31). Austin wheat is not *quite* resistant to leaf rust, since it suffered heavily in 1947 (p. 37).

Stripe rust has been known in the United States only since 1915, although it is now known to have been in the country since 1892 (p. 38). The author mentions only the less prevalent "dwarf bunt" form of *Tilletia caries*. The life history and extensive research on the common form and the numerous resistant varieties that have been developed have been completely overlooked (pp. 52, 57). Head smut of sorghum is considered to be "too rare to warrant special efforts at control" despite its common occurrence in Minnesota for many years (p. 59). Yellow berry of wheat, which is listed as a disease, is merely the result of starch deposition in excess of a supply of protein sufficient to form a corneous matrix in the endosperm. Also yellow berry wheat is erroneously stated to be "low in test weight" (p. 369). The author falls into the common error of confusing soil alkalinity with soil salinity (p. 377).

Chester's book is the most readable text on plant pathology the reviewer has encountered. The forthright style, however, often fails to allow for necessary qualifications and exceptions to the general rule.

JOHN H. MARTIN

THE NATURE AND PREVENTION OF THE CEREAL RUSTS AS EXEMPLIFIED IN THE LEAF RUST OF WHEAT. *Annales Cryptogamici et Phytopathologici (incorporating Annales Bryologici), Volume IV.*

By K. Starr Chester. Chronica Botanica Company, Waltham, Massachusetts; Stechert-Hafner, New York. $5.00. xvi + 269 pp.; ill. 1946.

This monograph reviews and interprets the literature on the cereal rusts from early times up to the present. A valuable feature is the review of contributions in more than 50 papers published in the Russian language, which the author himself had previously translated. The book is greatly strengthened and amplified by inclusion of the author's views, along with contributions from the literature on cereal rusts. As the title indicates, the different cereal rusts are discussed, but with major emphasis on the leaf rust of wheat, which has been the chief subject of the author's own rust investigations.

The book consists of 15 chapters and an extensive bibliography. It covers the history, origin, distribution, and economic importance of the rusts, the effect of rust on the host plant and its yields, susceptible hosts of cereal rusts, and the symptomatology and etiology of the rust diseases in the first six chapters. Two chapters are devoted to physiologic specialization, two others to factors affecting rust survival and development, and one chapter to rust dissemination, annual cycles, and epiphytotics. The last four chapters discuss the control of rusts by natural, regulatory, and cultural methods, by the use of fungicides, and by rust resistance.

The important contributions of the author are a critical analysis of the factors involved in the dissemination, disease attacks, and control of the rusts, and the evaluation of differential host varieties for determining physiologic races of the rust organisms. The book is a valuable contribution to the knowledge of cereal rusts. It is unfortunate that it could not have been enlarged to cover the stem rusts of cereals and their alternate host plants more completely.

JOHN H. MARTIN

PFLANZLICHE INFEKTIONSLEHRE. *Lehrbuch der Allgemeinen Pflanzenpathologie für Biologen, Landwirte, Förster und Pflanzenzüchter. Lehrbücher und Monographien aus dem Gebiete der exakten Wissenschaften, 3. Reihe der experimentellen Biologie, Band I.*

By Ernst Gäumann. Verlag Birkhäuser, Basel. S.Fr. 48.50 (cloth); S.Fr. 44.50 (paper). 611 pp.; ill. 1946.

Though described by the author as a textbook of general pathology for biologists, agriculturists, foresters, and plant breeders, this book is virtually a monograph on the biology of plant disease. Unlike most textbooks in this field, it gives no detailed discussions of individual plant diseases, but rather a comprehensive delineation of the biological principles that apply to plant diseases generally. The author's international viewpoint and wide grasp of the world literature have enriched the text with a wealth of pertinent examples selected from an appended bibliography of 600 titles.

The material is divided into chapters dealing with the nature and ecology of infection, the parasitic properties of pathogens, the predisposition and disease reactions of host plants and their modification by the environment, and the course and manifestations of disease, with fewer than six pages devoted to disease control.

As in the author's earlier *Biologie der Pflanzenbewohnenden parasitischen Pilze* (with E. Fischer, 1929), which this book somewhat resembles, particular emphasis has been laid on the dynamic defensive reactions of plants, and the hundred pages devoted to this important and often neglected phase of plant disease biology represents a particularly valuable contribution.

Many plant pathologists are apprehensive or dismayed at seeing their science becoming more and more an *Anhang* to crop production. The reason is that they have neglected the fundamental biological principles of their science in efforts to cater to the ad hoc considerations of agriculture. Gäumann's book should prove to be both an inspiration and a valuable aid to those teachers whose desire is to preserve and develop an autonomous science of plant pathology, as well as a useful reference work for any biologist whose horizon of professional interest includes parasitism in plants.

K. STARR CHESTER

DISEASES OF FIELD CROPS. *McGraw-Hill Publications in the Agricultural Sciences.*

By James G. Dickson. McGraw-Hill Book Company, New York and London. $4.50. xii + 429 pp.; ill. 1947.

This book is an up-to-date expansion of class outlines that had previously been processed and distributed by the Burgess Publishing Company, Minneapolis. It covers the diseases of most of the field crops of the United States. The diseases of other field crops, such as sugar beets, field peas, field beans, and potatoes, were deferred for inclusion in a book on diseases of vegetable crops, by J. C. Walker, to be published in the same McGraw-Hill series of publications in the agricultural sciences.

Section I of the book consists of the Introduction and a chapter on the Physiological Anatomy of Plant Groups in Relation to Disease. In Section II are 10 chapters devoted to the diseases of the different grains and grasses. Section III consists of three chapters covering the diseases of alfalfa, sweetclover, clover, and soybeans. Section IV consists of three chapters describing the diseases of cotton, flax, and tobacco. The appendix includes two running tables that list the various field crop diseases according to the causal factor or causal organism of each. Each chapter is followed by an extensive list of references.

The book will serve as a convenient reference on the diseases of the crops that are included, but many of these diseases are discussed much too briefly for complete coverage. A further expansion of the subject matter would be very helpful to the casual reader. A more critical reading and proof-reading would have eliminated the frequent misspellings, incorrect initials of authors, and other minor errors, e.g., Jensen, a Dane, is listed as being in Sweden. The most serious oversight was the failure to correct the indicated magnification of the illustrations of spores that were reduced for reproduction. This is unfortunate since spore size is an important character for identification. *Diseases of Field Crops* is a very useful and valuable contribution to the literature of the subject.

JOHN H. MARTIN

ALCALOÏDES ET PLANTES ALCALOÏFÈRES. *"Que Sais-Je?" Le Point des Connaissances Actuelles.*

By F. Moreau. Presses Universitaires de France, Paris. 75 fr. (paper). 128 pp.; ill. 1946.

This volume, one of the series of popular French handbooks of knowledge known as "Que sais-je?", deals with alkaloids and alkaloid-bearing plants. Part I comprises a general discussion and treats such topics as the general nature of alkaloids, their biological role, physical and chemical properties, chemical classification, and physiological characteristics, together with a list of alkaloid-bearing plants arranged by families.

Part II is devoted to short monographs of the more important species which contain alkaloids. A description of each plant, its distribution, and the nature, history, general properties, and therapeutic uses of the specific alkaloids are considered. The plants discussed include aconite; the opium poppy; tobacco; the mydriatic Solanaceae (*Atropa, Hyoscyamus,* and *Stramonium*); quinine; the caffein-plants (coffee, tea, maté, cacao, kola, guarana); colchicum; coca; *Conium;* the arrow and ordeal poisons, *Physostigma venenosum, Strychnos nux-vomica, S. ignati* and *S. toxicaria* (curare); ergot; and *Amanita muscaria* and the other mushrooms which contain muscarine and myco-atropine. Most of the species are illustrated by line drawings.

ALBERT F. HILL

LONG VEGETABLE FIBERS: *Manila, Sisal, Jute, Flax, and Related Fibers of Commerce.*

By Ludwig Weindling. Columbia University Press, New York. $5.00. xx + 311 pp. + 3 plates. 1947.

This monographic study of the long vegetable fiber industry fills a great gap in our available information regarding economic plants. Plant fibers, other than cotton and wood, have been much neglected in the past, and the only comprehensive works have been of foreign origin.

The present book, written by an engineer with first-hand knowledge of the field, attempts to marshall all the pertinent facts regarding the industry in all parts of the world, but with special emphasis on the American scene. The author's purpose, stimulated by the advent of the Second World War, is to present the commercial aspects of the industry in order to furnish a statistical background for national planning, and to bring together in one place the essential technical information and industrial statistics regarding fibers.

He includes such topics as the importance of the industry in peace-time and in war; the present and possible future sources of raw materials; the mechanism for distribution; the nature and amount of imports; and various specialized economic aspects, such as the amount of capital investment, the number of employees and their wage scales, and the quantity and value of the output.

The first three chapters are introductory in nature and deal with the uses and development of vegetable fibers, their characteristics and the general economic aspects of the industry. Seven chapters are devoted to the hard fibers, used chiefly for cordage and binder twine; and another seven to the soft fibers utilized in the manufacture of textiles. In each case the physical and chemical characteristics of the fiber are given, as well as the methods of cultivation, harvesting, decortication, data regarding commerce, grades, qualities, statistics as to acreage, output and international trade,

and a discussion of the manufacturing industry in some detail.

The hard fibers included are manila hemp, sisal, istle, New Zealand hemp and Mauritius hemp, with chapters on cordage and other hard fiber manufactures and the cordage industry in the United States and Canada. The soft fibers described are jute, with chapters on jute manufacturing and the jute industry; flax, with an account of the linen industry and linen manufacturing; hemp; sunn hemp and ramie.

Well expressed and interestingly written, with some fifty tables and an adequate index, the book should appeal not only to readers who are specialists in economic planning, in general commerce, or in the textile industry, but to anyone interested in useful plants as well.

ALBERT F. HILL

FOREST VALUATION, *With Special Emphasis on Basic Economic Principles. The American Forestry Series.*

By Herman H. Chapman and Walter H. Meyer. McGraw-Hill Book Company, New York and London. $6.00. xii + 521 pp. 1947.

This textbook, designed primarily for use in courses in forest economics, management, or finance, is the successor of *Forest Valuation* (1925), and *Forest Finance* (1935). It presents a modern treatment of these fields and is especially noteworthy for its emphasis on the application of ordinary basic economic principles to forest valuation. These fundamental economic laws are outlined in the six introductory chapters. The basis of all the economic discussions in the book is the idea of a competitive economy founded on private initiative and free markets. The importance and economic role of public ownership and operation, however, is given proper consideration.

The book covers a wide field and is up to date in its approach. Discount (the key to all sound appraisals of value) is stressed throughout, along with detailed analyses of grade composition and value of standing timber. By emphasizing the fundamental laws of economics in their direct relation to all phases of forest economics and valuation, the authors make their subject more vital and bring out its importance both to professional foresters and to owners and operators of forest properties as well.

ALBERT F. HILL

SMALL-FRUIT CULTURE. *A Text for Instruction and Reference Work and a Guide for Field Practice. Second Edition.*

By James Sheldon Shoemaker. The Blakiston Company, Philadelphia and Toronto. $4.00. viii + 433 pp.; ill. 1948.

The ready acceptance and desirability of frozen-packed foods, the availability of home freezers, and the feasibility of small-fruit culture even in suburban areas makes the second edition of this volume a particularly welcomed one. Although essentially a textbook, and thoroughly documented with references from original research papers, it is still a readable and useful book for the home owner whose space is limited but whose gardening urge is strong. Each of the fruits discussed is a commercially important one, and each is considered under the following topics: commercial importance, regional distribution, variety characteristics and preferences, yield versus cost, propagation methods, cultural practices, and marketing and storage procedures. Recent information on sprays, new varieties, frozen-pack preservation, and improved cultural practices, as well as new sections on the youngberry, the boysenberry, and the vinifera and muscadine grapes brings the book up to date. The book has much to recommend it to the small-fruit grower, whether commercial or amateur. It suffers, however, from very poor reproductions of the photographs.

C. P. SWANSON

TROPICAL AND SUBTROPICAL FRUITS. *Popular Series, Botany, Number 26.*

By B. E. Dahlgren; drawings by Albert Frey. Chicago Natural History Museum, Chicago. 50 cents (paper). xii + 72 pp. + 1 plate; text ill. 1947.

This little book, the most recent of the Popular Series of Botanical Publications issued by the Chicago Museum of Natural History, is devoted to the more important edible fruits of the tropics and subtropics. A brief historical introduction precedes the text, which deals with 28 fruits of Old World origin and 37 which are natives of the New World. The excellent illustrations, from pen and ink drawings made by Albert Frey, are supplemented by brief but adequate descriptions of the plant and pertinent facts regarding the fruit in question. The scientific names are accurate, and the vernacular names used in the American tropics are also given. The reader who wishes more detailed information will find available a bibliography of 27 titles. An index is appended. All in all this work should aid materially in acquainting the public with these increasingly important products of the tropics.

ALBERT F. HILL

VERZAMELDE RAPPORTEN VAN PROEVEN IN ZAKE HET BEWAREN EN HET KOELEN VAN UIEN 1940–1942. *I. Het bewaren van uien in een fruitbewaarplaats; II. Het bewaren en het koelen van uien; III. Het ascorbinezuurgehalte van bewaaruien. Mededeelingen en Overdrukken*

van het Instituut voor Onderzoek op het Gebied van Verwerking van Fruit en Groenten te Wageningen, Series I, Number 9, April, 1943.

(I) By T. Van Hiele, (II) by J. H. M. Van Stuivenberg, (III) by H. J. Mathot. H. Veenman & Zonen, Wageningen. f. 1.- (paper). 56 pp. + 2 plates; text ill. 1943.

FACTOREN DIE DE VARIATIE VAN HET VITAMINE C IN DE PLANT BEPALEN. *Mededeelingen van het Instituut voor Onderzoek op het Gebied van Verwerking van Fruit en Groenten te Wageningen, Series I, Number 15, December, 1945.*

By H. J. Mathot. H. Veenman & Zonen, Wageningen. f. 3.- (paper). ii + 176 pp.; ill. 1945.

HET VITAMINE-C-GEHALTE VAN VROEGE AARDAPPELEN, BEPALINGSMETHODE EN ORIËNTEEREND ONDERZOEK. *Mededeelingen en Overdrukken van het Instituut voor Onderzoek op het Gebied van Verwerking van Fruit en Groenten te Wageningen, Series I, Number 10, May, 1943.*

By H. J. Mathot. H. Veenman & Zonen, Wageningen. f. 0.50 (paper). 18 pp.; ill. 1943.

ONDERZOEKINGEN INZAKE DE TOEPASSING VAN CONSERVEERMIDDELEN BIJ DE BEWARING VAN AARDAPPELEN. *Mededeelingen van het Instituut voor Onderzoek op het Gebied van Verwerking van Fruit en Groenten te Wageningen, Series I, Number 16, July, 1946.*

By T. Van Hiele, J. H. M. Van Stuivenberg, and H. Veldstra. H. Veenman & Zonen, Wageningen. f. 6.50 (paper). iv + 176 pp. 1946.

GENERAL AND SYSTEMATIC ZOOLOGY

ZOÖLOGY.

By Theodore D. A. Cockerell. Reese Publicity Company, Baltimore. $1.00. xii + 558 pp. 1947.

T. D. A. Cockerell was the last survivor of that illustrious assemblage of naturalists of the Victorian era of which Charles Darwin was the most celebrated example. Cockerell never met Darwin personally, but he was well acquainted with Alfred Russel Wallace, who entrusted to him the preparation of the text for the revised edition of *Island Life*, and also recommended Cockerell to Francis Galton, when the latter was looking for someone to supervise the establishment of the Galton Laboratory at the University of London.

While yet a young man, Cockerell was threatened with tuberculosis and came to New Mexico for his health. Finding the Mollusca, his special field of study, to be but sparsely represented in this environment, he turned his attention to bees, eventually becoming a great authority on them. When, at the close of the second world war, it was learned that the hasty evacuation of the British Museum had precipitated a hopeless shuffle of the labels on the African bees, this entire collection was sent to Cockerell at the Desert Museum at Palm Springs for rehabilitation, no other person being considered competent to accomplish this task.

The recent death of Cockerell makes a review of the reprinting of one of his best known works seem especially timely. Written originally for use in his own teaching in the University of Colorado, it became very popular in the schools of Great Britain, and when so many of that nation's school libraries were destroyed in the blitz the demand for a new printing arose. The current paper-bound edition was hurriedly printed to meet this demand. It consists of sixty-six fully independent chapters, which cover various aspects of zoological science—taxonomy, ecology, paleontology, genetics, zoogeography, to name a few, interspersed with brief biographical sketches of such figures as Darwin, Pasteur, Fabre, Agassiz, and others. In this way the book strongly emphasizes the cultural value of the study of zoology, and the inclusion of an original poem as the closing chapter bears witness to the fact that Cockerell was not only a scientist but a poet as well. This poem merits reprinting here but for its length. Instead, perhaps the reviewer will be pardoned for closing with another poem of Cockerell's:

To Posterity

You will see where we are blind.
We may seek but you will find.
Yet as you hold the golden thread
Passed on from days of long ago,
The names of those remembered
For what they strove to do and know
May still have power to stir the mind
And passing, leave a gift behind.

A FIELD GUIDE TO THE SHELLS OF OUR ATLANTIC COAST.

By Percy A. Morris. Houghton Mifflin Company, Boston. $3.50. xviii + 190 pp. + 40 plates; text ill. 1947.

The title of this book is a misnomer. A field guide is a book which can be taken on field trips to enable the observer to identify his material as soon as he encounters it. Since it is obviously impossible for an observer to visit both the New England and Gulf coasts on the same trip, it is clear that this book attempts to cover too wide a geographic range to be a successful field

guide. The explanation doubtless lies in the fact that Roger Tory Peterson, who edited the series to which this book belongs, is a bird man, and many birds are migratory and cover vast ranges. But mollusks do not migrate, and each marine molluscan fauna is confined to an area within which the temperature is fairly constant. Thus the faunas from the two sides of Cape Cod differ fundamentally, and the same is true of Cape Hatteras and to a lesser degree of Cape Canaveral. The geographic range covered by a field guide to mollusks should therefore be bounded by capes which divert oceanic currents from the shore, causing discontinuity of temperature and demarking faunal limits.

Furthermore, when the scope of a field book is extended to cover several provinces it is obvious that no one of them can be accorded as careful attention as if the book were concentrated upon it alone. The present work does not include all the species which a casual observer might encounter on a visit to the shore—it is impossible that a book of its size could do so. A selection must be made, and, while it must be conceded that the author has used excellent judgment in selecting those species which are most likely to be met with, the possibility always remains that the observer may pick up something not noted in his guide book—a very disconcerting experience.

Again, the ornithologists seem to be able to get along quite well without using any subgeneric or sectional terms. How they can do this is one of the unsolved mysteries of science. While the omission of such nomenclatorial nuisances does simplify the taxonomy it is also likely to give the beginner a false sense of security as to the stability of nomenclature. When he later learns what great disagreement obtains among authorities as to the relative ranks of certain groups, and finds that the same species may be assigned to half a dozen nomenclatorial units by as many writers, he is likely to become disconcerted if not discouraged. The same holds true for the omission of authority citations; while the printed page does look cleaner and neater without them it must be remembered that the malacologist, whether he likes it or not, cannot confine his attention to shells alone, but must also consider such things as bibliographic references, synonyms, and homonyms, and that he is not immune to that perennial headache—the availability or unavailability of the names proposed by such writers as Martyn, Chemnitz, or Bolten. Whether or not polemic matters of this sort find a place in a field guide, it remains true that the authority citations should have been given; even though the reviewer cannot help feeling admiration for an author who has the fortitude to fly in the face of the International Commission on Zoological Nomenclature by omitting them altogether.

If the reader has by now gotten the idea that the reviewer disapproves of this work, it is unfortunate, for such is not really the case. Perhaps the trouble is that, being a resident of the Pacific coast, he is unconsciously resentful of the fact that we have no Percy A. Morris in the west (where we need one badly); perhaps he is jealous of the many beautiful colored illustrations, which his own work lacks because his publisher felt that recourse to such would not be justified; or perhaps, having already written another review of this book (which was really quite enthusiastic), he has now gone stale.

A field book is always a necessary tool for the outdoor naturalist. The convenient pocket size of this book, the clarity of its illustrations, the scientific accuracy of its descriptions, its glossary of three pages and its index of seven, all serve to make it an excellent example of what a field book should be. It will be found especially helpful by the beginner.

INTRODUCTION À L'ENTOMOLOGIE. *I. Anatomie Generale et Classification. Nouvel Atlas d'Entomologie, Number 1.*

By R. Jeannel, with illustrations by Germaine Boca and Mme Bouisset. Élitions N. Boubée & Cie., Paris. 180 fr. (paper). 83 pp. + 10 plates; text ill. 1945.

INTRODUCTION À L'ENTOMOLOGIE. *II. Biologie. Nouvel Atlas d'Entomologie, Number 1.*

By R. Jeannel, with illustrations by Germaine Boca and Mme Bouisset. Élitions N. Boubée & Cie., Paris. 180 fr. (paper). 105 pp. + 10 plates; text ill. 1946.

INTRODUCTION À L'ENTOMOLOGIE. *III. Paléontologie et Peuplement de la Terre. Nouvel Atlas d'Entomologie, Number 1.*

By R. Jeannel, with illustrations by G. Boca and M. A. Descarpentries. Éditions N. Boubée & Cie., Paris. 180 fr. (paper). 101 pp. + 14 plates; text ill. 1946.

ATLAS DES LÉPIDOPTÈRES DE FRANCE. *I. Rhopalocères. Nouvel Atlas d'Entomologie, Number 6.*

By F. Le Cerf, with illustrations by Roger Métay. Élitions N. Boubée & Cie., Paris. 250 fr. (paper). 115 pp. + 12 plates; text ill. 1944.

ATLAS DES COLÉOPTÈRES DE FRANCE. *I. Carabes, Staphylins, Dytiques, Scarabées. Nouvel Atlas d'Entomologie, Number 9.*

By Luc Auber, with illustrations by Germaine Boca. Élitions N. Boubée & Cie., Paris. 180 fr. (paper). 83 pp. + 12 plates; text ill. 1945.

ATLAS DES COLÉOPTÈRES DE FRANCE. *II. Ténébrions, Buprestes, Lampyres, Coccinelles, Taupins, Longicornes. Nouvel Atlas d'Entomologie, Number 9.*

By Luc Auber, with illustrations by Germaine Boca. Élitions N. Boubée & Cie., Paris. 180 fr. (paper). 83 pp. + 12 plates; text ill. 1946.

ATLAS DES COLÉOPTÈRES DE FRANCE. *III. Longicornes, Chrysomèles, Charançons. Nouvel Atlas d'Entomologie, Number 9.*

By Luc Auber, with illustrations by Germaine Boca. Élitions N. Boubée & Cie., Paris. 180 fr. (paper). 89 pp. + 12 plates; text ill. 1947.

Fashioned after the same plan as the *Atlas des Parasites des Cultures* previously reviewed here (Q. R. B. 23: 77), these little volumes exhibit the same high quality of workmanship. The three volumes which constitute an *Introduction to Entomology* treat of general anatomy, classification, biology, paleontology, and world distribution. Discussed in turn are the systematic position of the Insecta, the better known theories of their phylogenetic origin, external and internal morphology, embryological and postembryological development, and classification of the higher categories. Under the heading of biology are treated nutrition, excretion, respiration, circulation, sensory perception, tropisms, reproduction, behavior, mimicry, parasitism, learning, and social behavior. The section on paleontology and distribution discusses the subject in considerably more detail than most American general text books.

The volumes on Lepidoptera and Coleoptera, while devoted chiefly to the taxonomy of French species, contain by way of introduction valuable information on structure, biology, methods of collecting, etc.

One feels constrained to repeat that an American counterpart to these delightful volumes would be an asset to laymen and professional entomologists alike. The illustrations, as before, are beautiful and helpful, representing standards of artistry and color-printing far above American standards.

V. G. Dethier

Checklist of the Coleopterous Insects of Mexico, Central America, the West Indies, and South America. *Part 5. Smithsonian Institution, United States National Museum, Bulletin 185.*

Compiled by Richard E. Blackwelder. United States Government Printing Office, Washington, D. C 60 cents (paper). iv + Pp. 765–925. 1947.

A Revision of the American Species of Hoplitis (Hymenoptera, Megachilidae). *Bulletin of the American Museum of Natural History, Volume 89, Article 4.*

By Charles D. Michener. American Museum of Natural History, New York. 75 cents (paper). Pp. 257–318; ill. 1947.

With this monograph C. D. Michener adds still another exemplary work to his fine biologic and taxonomic studies of bees. Eight subgenera of *Hoplitis*, a genus of leaf-cutting bees, are recognized within our fauna, encompassing some 24 species and 15 subspecies. Keys are provided to both subgenera and species, and detailed descriptions are given for each of the taxonomic entities recognized. The range for each species, where at all reasonably well known, is portrayed in distributional maps. Brief treatment is given to the bionomics and phylogeny of *Hoplitis*. In addition there is a more detailed discussion of the possible course of evolution within *Alcidamea*, the more dominant and best known of the subgenera found in North America. Several species are figured in toto; and outline drawings of mandibles, as well as of antennae and apical abdominal segments of males, are provided in illustration of key and descriptive characters.

Kenneth W. Cooper

The Insect World.

By Hilda T. Harpster; illustrated by Zhenya Gay. The Viking Press, New York. $3.00. xii + 211 pp.; ill. 1947.

The author presents a surprisingly informal survey of interesting insects, drawing upon her particular familiarity within this group. The various kinds are introduced in a very natural way in informative discussions of how insects grow, what they eat, how aquatic kinds breathe, or of such special features as protection, camouflage, and homes. The account of crickets in China kept as pets is especially complete, as is a lively introduction to the various silkworms and their culture in Asia and southern Europe. An appendix provides a simple table of ten common orders of insects with their general recognition features, and a survey of some twenty-three different types with descriptions and suggestions as to where to look for them. The style throughout should appeal to readers at the high school level, and make information pleasantly available to parents who are puzzled by the caterpillars and bugs their children bring home and ask about.

Lorus J. & Margery J. Milne

Festschrift Zum 60. Geburtstage von Professor Dr. Embrik Strand. *Volumes II and III.*

"Latvija," Riga. Paper. (II) ii + 652 pp. + 37 plates; text ill. (III) ii + 608 pp. + 20 plates; text ill. 1936–1937.

These two volumes have been greatly delayed in arrival in the United States because of the war. They contain a total of 89 papers written in honor of the arachnologist Embrik Strand by friends and colleagues abroad. The subjects fall almost wholly within the realm of the Arthropoda, paleontological and living, and the papers are published in German, English, French, or Italian.

VARIATION IN THE SKINKS (REPTILIA: LACERTILIA) OF THE SKILTONIANUS GROUP. *University of California Publications in Zoology, Volume 48, Number 4.*

By Thomas L. Rodgers and Henry S. Fitch. University of California Press, Berkeley and Los Angeles. $1.00 (paper). Pp. 169–220; ill. 1947.

When a thorough monographic treatment of a genus appears, investigators, considering it relatively definitive, breathe a sigh of relief, and thankful for the conclusion of a particular segment of work turn their efforts elsewhere. Such a monograph was Taylor's 643-page study of the genus *Eumeces* (1935. *Bull. Univ. Kansas*, 36(14): 1–643, 84 figs., 43 plates). The paper under consideration here is concerned with the skiltonianus group of that same genus *Eumeces*. Its appearance, just a dozen years after Taylor's monograph, is a monument to the labors of the authors, particularly to their extensive field work (largely by Fitch), and thoughtful methods of recording and presenting their data (largely by Rodgers). More than that, it is an indication that taxonomic work is not passé. Sound systematic studies constitute an important and active subscience, even as the more widely acclaimed experimental phases of biology. Careful work by careful workers—this paper is an example—can contribute much to our store of biological knowledge.

The systematic details recorded are of interest only to specialists in the field. Suffice it to say that there are recognized here three species of *Eumeces: skiltonianus, lagunensis*, and *gilberti*, the last with four subspecies, one of which is described as new. These skinks range from British Columbia south through Lower California and east into eastern Idaho.

After the introductory material there is a general discussion of habitat and distribution, which is followed by a key. Because of the tremendous ontogenetic variation in these lizards, the authors have deemed it necessary to include the area of collection as part of their identification key. This is unfortunate. There is next a consideration of intraspecific variation: age, sexual, and individual. The discussion of interspecific variation is divided into two parts: size, relative limb length, and scalation and color. There then follows an account of the species, a summary, a list of literature, and plates. Features of the paper include a number of Dice-Leraas graphs and a series of semidiagrammatic colored plates that illustrate ontogenetic changes and sexual dimorphism of color pattern.

Unfortunately there are indications in the monograph of confused concepts (which are widespread in the literature) regarding biometrical analysis, e.g., "...it is possible accurately to determine the individual and group variations only when the series of specimens analyzed are large enough to be treated statistically" (p. 178). All of the common formulae in current use contain an expression for the number of specimens (N), and there are several special correctional devices for dealing with small samples. It is, in fact, possible to treat single specimens statistically. The number of specimens alone does not indicate satisfactorily whether a reasonable idea of variation may be obtained. Other statistical and biological factors must necessarily be involved. It is, as a matter of fact, quite possible to obtain, for example, a satisfactory estimate of the variation of the labial scales from a series of lizards and yet be unable to obtain a satisfactory estimate of the variation of the dorsal scales from that identical series of specimens.

ARNOLD B. GROBMAN

OCEANIC BIRDS OF SOUTH AMERICA. *A Study of Species of the Related Coasts and Seas, Including the American Quadrant of Antarctica Based Upon the Brewster-Sanford Collection in the American Museum of Natural History. Volumes I and II.*

By Robert Cushman Murphy. The Macmillan Company, The American Museum of Natural History, New York. $17.50. (I) xxii + Pp. 1–640 + 44 plates; text ill.; (II) viii + Pp. 641–1246 + 44 plates; text ill. 1936.

Naturalists who are familiar with this classical work will be pleased to know that it is now available from the Macmillan Company in essentially the form in which it was presented by the American Museum of Natural History (Q. R. B. 11: 351. 1936). The only outstanding change which has been made is that in this printing the color plates and photographic illustrations are not scattered through the text, but are assembled at the end of each volume.

The reviewer would like to comment on this study for the benefit of those who are not yet acquainted with it, for this is no mere check list of oceanic birds. Rather, it represents one of the outstanding accounts not only of the behavior and characteristics of the sea and littoral birds of South America, but of the various geographical and climatic features governing their distribution and activities. The book is presented in two sections that cover both the Atlantic and Pacific sides of the continent, including the adjacent oceanic islands. The first section describes in great, yet significant, detail the various environmental features of the areas studied, while the second and larger portion of the work presents individual life histories of such birds as kelp geese, steamer ducks, and penguins, albatrosses, and petrels. Careful consideration is given to the guano birds and other island forms. The material is presented in an extremely interesting manner, so that the reader feels as though taking part in the various expeditions upon which the work was based.

A final point of note is the vivid picture drawn of the field work involved in extracting information of this

sort from nature and of the spirit that lies behind such work. That spirit is personified not only in Robert Cushman Murphy's own researches, but, as he brings out, also in the collecting of the R. H. Becks and the several others whose endeavors and financial support have resulted in this fine story of life in wild and remote regions.

JOHN E. CUSHING

BIRDS IN THEIR HOMES.

By Addison Webb; Pictures by Sabra Mallett Kimball. Garden City Publishing Company, Garden City, New York. $2.00. 66 pp.; ill. 1947.

A children's book which should interest anyone from five to fifty, this volume tells of the many diverse ways by which the birds have solved their housing problems. From the fastidious hummingbird which uses plant downs, spiderwebs, and lichens for building materials to the lazy cowbird with no nest, the reader is carried through the initial stages of site selection, construction processes, egg laying, and family life of some 25 species of our more common birds. The text is simple yet adequate, and the illustrations, both colored and black and white, are beautifully done. The book should be made accessible to every inquisitive youngster.

C. P. SWANSON

STARLINGS.

By Wilfrid S. Bronson. Harcourt, Brace and Company, New York. $1.75. 78 pp.; ill. 1948.

Written for children, this is nevertheless the kind of book that adults can approve and enjoy. Both text and illustrations are clever and informative. In fact, the bird drawings set a very high standard of achievement both for dramatic appeal and for expertness of draftmanship. And the story of the starlings—their lives and times—is told with a zest, an accuracy, and a lack of sentimentality that sets this book in a class by itself. The entire atmosphere of the book is of good-humored realism. The starlings eat the right foods, the males sing for the right reasons (according to modern theory), and both sexes commit the appropriate nuisances. Anyone who has stopped to hear a starling singing on a winter day will want to see the book, and it should be a must for every school library.

ANN F. MOMENT

BIRDS OF PREY OF NORTHEASTERN NORTH AMERICA.

By Leon Augustus Hausman; Illustrated by Jacob Bates Abbot, Frontispiece by George Miksch Sutton. Rutgers University Press, New Brunswick. $3.75. xxviii + 164 pp.; ill. 1948.

As the title would imply, the birds concerned in this publication are members of the hawk and owl groups that occur in the northeastern part of North America. This includes stragglers normally found elsewhere, like the sea eagle, but which have been reported on occasion in the northeastern area. In all, 35 species and subspecies are described. This description for each type of bird includes brief plumage notes, length of body and wingspread, general notes on the life history, especially food habits, and distribution. None of these topics is discussed in great detail. Illustrations by Abbot are excellent. An index and bibliography are supplied. The naturalist, sportsman, or farmer will find this a useful book to remind him of the value of these fine birds. In addition, many will enjoy the handsome layout of this book, with its attractive cover and printing.

HENRI C. SEIBERT

THE BIRDS OF NANTUCKET. *New England Bird Studies, Number 1.*

By Ludlow Griscom and Edith V. Folger. Harvard University Press, Cambridge; Geoffrey Cumberlege, Oxford University Press, London. $3.25. xii + 156 pp. + 17 plates. 1948.

A knowledge of the changes that occur in bird populations over a long period of time is of considerable value and significance, since it offers a means whereby the possible effects of alterations in environmental conditions can be evaluated. Unfortunately, there are scant published data which are sufficiently comprehensive to afford significant comparisons with more recent observations. The senior author of this book, however, has had access to William Brewster's unpublished notes and diaries. Enough information was included therein to enable valuable comparisions to be made on many species of birds on Nantucket Island in 1870 with the bird population present within the last two decades. The junior author has provided the more recent records.

Because of a lack of continuous observation on the island, even today the exact status of many common birds is not certain. Land birds and shore birds are scarce compared to the mainland. As would be expected on an offshore island, there are unusual records of vagrants and casuals. For some species, the reason for the change in population numbers can only be conjectured (except for those birds formerly hunted as game and now protected); for others, interspecific competition, as between laughing, herring, and great black-backed gulls, or changes in environment, as the planting of pines and appearance of the pine warbler, show fairly definite cause and effect.

The introduction discusses climatic factors, land bird migrants, changes in bird life and their causes.

It also provides a historical summary of Nantucket bird students and a digest of ornithological problems that still await solution. The systematic list includes the comparisons already alluded to, special effort having been made to provide definite figures or counts. The bibliography appears to be comprehensive, an index is present, and a detailed map of the island has been included. To illustrate an excellent text, photographs, mostly by the hand of that excellent technician, Alan D. Cruickshank, have been generously supplied.

HENRI C. SEIBERT

WILD BIRD NEIGHBORS.

By Alvin M. Peterson. Wilcox & Follett Company, Chicago. $2.50. vi + 298 pp. + 1 plate; text ill. 1947.

This book is a popular account of the author's personal experiences with the birds of his region (no locality mentioned). Most of the information deals with the nesting phase in the bird's life cycle. From the number of nests of various species that are discussed, it is apparent that the author has spent many years in the field. Many of the nesting birds were photographed, and considerable space is devoted to a description of the trials and tribulations of the bird photographer. The results of these endeavors illustrate the book, but unfortunately the printing does not do the author full justice. At the risk of being pedantic, one would like to warn readers not to take the author's interpretations of bird behavior too literally. "No doubt this was the way of showing how happy they were [kingbird] . . ." "The cowbird is either too lazy or unskillful to build a nest. . ." ". . .he [brown thrasher] was so happy he could not refrain from singing, but was wise enough to sing in low tones. . ." Although the author recognizes that there are good and bad birds and that each has its place in the natural scheme of life, yet on occasion he does not hestitate to pass a death sentence on a hawk because it molests the bob-white, or on a blue jay for killing a bluebird. "Naturally, I shot the jay on the spot."

HENRI C. SEIBERT

WILD WINGS.

By Joseph James Murray. John Knox Press, Richmond. $2.50. 123 pp. + 14 plates. 1947.

These sketches of bird life, with but minor revisions, first appeared in *Onward*, the young people's paper of the Presbyterian Church in the United States. The last chapter, "Behold the Fowls of the Air," originally appeared in the *Audubon Magazine*. The material was derived from observations made at home (in western Virginia), in regions of the southeastern part of the United States (Great Smokies, Dismal Swamp, Everglades, etc.), and in parts of Europe. The last part of the collection is devoted in large measure to a discussion of birds from the Old and New Testaments and the role they played in the allusions and aphorisms of Jesus. The author is a pastor as well as a reputable ornithologist, and after reading his book it is further evident that he is an enthusiastic observer of nature and an excellent writer, a series of traits which, when happily blended together, make for pleasurable reading. The illustrations were taken from the files of the National Audubon Society, and are mostly those of A. D. Cruickshank.

HENRI C. SEIBERT

WHEN I HID IN THE MARSH.

By B. Melville Nicholas. Andrew Dakers, London. 6s. 128 pp. + 25 plates. 1946.

The author has spent many hours wandering in the marshes and moors of England, the favorite haunt of a host of interesting birds. There, hiding in some concealing vegetation or in an artificial blind, he observed at first hand the activities of herons, grebes, snipe, owls, plovers, kingfishers, curlews, marsh warblers, and others. Even some of the marsh-inhabiting mammals, such as the otter, are included in the list. These intimate reports on the lives of these creatures will bring pleasure to nature lovers, whether or not they are personally familiar with the birds in question. The illustrations were chosen from some of England's leading nature photographers, although none is specifically accredited to any individual.

HENRI C. SEIBERT

THE BIRDS OF BREWERY CREEK.

By Malcolm MacDonald; illustrated by Arthur A. Allen and W. V. Crich. Geoffrey Cumberlege, Oxford University Press, London, Toronto, and New York. $5.00. x + 334 pp. + 23 plates. 1947.

Brewery Creek obtained its name from a plant that is no longer in existence. In place of presses and vats, the area now has a rather wild aspect, even though only a short distance from the heart of Ottawa. It is in this locality that the author describes the bird scene, month by month. Nesting birds are given especial prominence, and their yearly cycle is reported, along with the changing climatic conditions and the progressive change in the flora. These events are written in a highly humorous style, but still with sufficient detail to make it apparent that the author has a keen and accurate eye. His frequent use of references attests to his acquaintance with the literature. Many of us who claim we are too busy to spend much time in the

field should read this book and learn how well a busy man like the High Commissioner for the United Kingdom to Canada can utilize a few spare moments to obtain sufficient information for a highly interesting contribution to bird study. The photographs, some of which are in color, are those of A. A. Allen and W. V. Crich.

HENRI C. SEIBERT

ORNITHOLOGY LABORATORY NOTEBOOK *For recording observations made in the field and studies made in the laboratory on the birds of North America. Fifth Edition.* *By Arthur A. Allen; with drawings by L. A. Fuertes, M. D. Pirnie, and William Montagna. Comstock Publishing Company, Ithaca, New York.* $4.00. viii + 256 pp. + 1 plate; text ill. 1947.

This fifth edition of A. A. Allen's field notebook has been expanded, with a view to making it of greater use to classes in the South and West, as well as in the East. It still retains its primary intent of serving an elementary class which is chiefly concerned with the recognition of birds and the first fundamentals of interpreting their behavior. The book contains illustrated keys to the orders, families, and nests of North American birds, life history charts of 104 birds, 24 check lists to be used on as many field trips, and various miscellaneous exercises.

JOHN E. CUSHING

WILD ANIMALS *of the Five Rivers Country.* *By George Cory Franklin; illustrated by Mary Ogden Abbott. Houghton Mifflin Company, Boston.* $2.50. viii + 271 pp. + 8 plates. 1947.

Here are 18 well-told, gripping stories about American mammals, in the vein of Ernest Thompson Seton. The author knows from long experience both his Five Rivers Country, on the Continental Divide in Colorado and New Mexico, and the animals he writes about. A great deal of animal lore is packed into these tales of antelope, porcupine, gray wolf, dog, wolverine, red fox and gray fox, skunk, beaver, snowshoe rabbit, black woodchuck, bighorn sheep, bob-cat, deer, pack rat, coyote, muskrat and cinnamon bear. This is a grand book for a boy, if his dad will let loose of it long enough for him to read it.

BENTLEY GLASS

CATS AND ALL ABOUT THEM. *Revised Edition.* *By L. H. Fairchild and Helen G. Fairchild, with an introduction by Belle J. Benchley. Orange Judd Publishing Company, New York.* $2.50. 243 pp.; ill. 1947.

This book is excellent for the new owner of a pet and also valuable for those interested in breeding and showing cats. It states in simple terms the everyday things and skillfully discusses the intricate details of the care and breeding of cats. Practical advice is given for the care of the well cat or kitten, and equally helpful are the detailed discussions of diseases and their treatment. The chapters on breeding, registering and showing, and the cattery are valuable to the cat fancier. The illustrations are good. A bibliography and index are quite helpful. The revised edition brings new and useful ideas to the cat owner.

HELEN S. WILLIER

RABBITS. *By Herbert S. Zim; Pictures by Joy Buba. William Morrow and Company, New York.* $2.00. 64 pp.; ill. 1948.

A good book for children on rabbits, centering on domestic rabbits, but considering also their wild relatives. Much information is presented in a simple manner about such topics as the ways to raise rabbits, their uses, and interesting habits. The illustrations are excellent, and add much to the attractiveness of the book.

WHAT ANIMAL IS IT? *By Anna Pistorius. Wilcox and Follett Company, Chicago, New York, and Toronto.* $1.00. 27 pp.; ill. 1947.

Attractive colored pictures of many animals common in zoos are presented, together with a paragraph of description about each. The names of these animals are left for the child to guess or look up in the key. The book is arranged in a way that should be interesting to children.

ELEPHANTS. *Morrow Junior Books.* *By Herbert S. Zim; pictures by Joy Buba. William Morrow and Company, New York.* $2.00. 63 pp.; ill. 1946.

This text deals largely with the trapping and training of elephants and offers many points besides regarding their structure and habits that ought to be of interest to children. The illustrations are fair and show a variety of elephant activities, both in the wild and in association with man.

DESERT ANIMALS. *By Rita Kissin; illustrated by Helene Carter. David*

McKay Company, Philadelphia. $2.50. 26 pp.; ill. 1947.

Children will enjoy this picture book of desert animals of our Southwest. Jackrabbits, iguanas, cactus wrens, roadrunners, horned toads, and other denizens of the arid regions are exceptionally well illustrated, and each has a short verse depicting some characteristic feature that the animal possesses. There can be no doubt that both the artist and the author have had first-hand experience with these creatures.

HENRI C. SEIBERT

THE CYPRINODONT FISHES OF THE DEATH VALLEY SYSTEM OF EASTERN CALIFORNIA AND SOUTHWESTERN NEVADA. *Miscellaneous Publications, Museum of Zoology, University of Michigan, Number 68. By Robert R. Miller. University of Michigan Press, Ann Arbor.* $2.00 (paper). 155 pp. + 15 plates + 3 maps + 1 table; text ill. 1948.

Probably one of the most curious fish faunas in the world is that found in the isolated springs of the Death Valley region. This fauna is composed of two genera of cyprinodonts, embracing a total of six full species. One species is found only in a small spring, and its total population varies from 50 to 400 individuals. These fishes, relicts of a more extensive Pleistocene water system, show evidence of comparatively rapid speciation, assisted by the smallness of the populations and in some cases the almost continuous breeding period in warm springs. Experiments in raising these fish in a different environment produced F_1 generations with essentially the same characters as natural populations, although there were exceptions which indicated an environmental influence on speciation.

J. W. HEDGPETH

ECONOMIC ZOOLOGY

THE ARTIFICIAL INSEMINATION OF CATTLE. *By John Hammond (Editor), J. Edwards, L. E. A. Rowson, and Arthur Walton. W. Heffer & Sons, Cambridge, Eng.* 3s. 6d. (paper). viii + 61 pp.; ill. 1947.

On the inside of the front cover of this tiny book is a statement that "the book is intended for the practical farmer, and the general public, and is not highly technical." Without being technical in the ordinary sense, the authors cover step by step almost every phase of artificial insemination in cattle. Twenty-eight pages of clear, concise English describe the technical methods, and the next 31 pages cover the organization and operation of centers for artificial insemination. If the authors have overlooked a point, this reviewer failed to find it. Obviously these men know their field, for they include enough detail for the farmer and enough references to give the more technically trained reader a start on the literature of the field.

In addition to simplicity and clarity of language, there are several other points on which the authors have done exceptionally well. The passage on psychological infertility (pp. 48–49) is particularly good. Printing the name and address of the manufacturer or supplier of specialized equipment is an improvement in a practical guide, and covering both the technique of artificial insemination and the organization of such centers makes this small book a complete guide for groups undertaking this rapidly expanding service.

ROBERT K. ENDERS

TRAPPING. *The Craft and Science of Catching Fur-Bearing Animals. By Harold McCracken and Harry Van Cleve; illustrated by Howard L. Hastings. A. S. Barnes and Company, New York.* $2.75. xii + 196 pp.; ill. 1947.

Successful methods of trapping North American fur-bearers are described by both an entertainingly written text and pen-and-ink sketches. For each mammal whose fur has any commercial value, whether skunk or black bear, the senior author has outlined its distribution and has included pertinent aspects of its life history. To the junior author has fallen the job of describing the trapping techniques. After reading this book, the inexperienced trapper will agree with the authors that experience is still the best teacher. However, this is not meant to imply that the authors have not succeeded in putting down on paper as much information as written exposition can supply. Furthermore, there is considerable information on the life habits of these important animals.

In discussing distribution, the ranges of the subspecies have been taken up in too much detail for a book such as this, and the space could otherwise have been more profitably used for additional illustrations, especially on skinning and tanning methods. The latter topics should have been described in more detail, for, after all, of what value is it to trap a fur-bearer if its pelt is not properly handled. The final chapter provides miscellaneous hints of a random nature for the outdoor man, such as waterproofing a tent, using a watch as a compass, how to make jerked venison, and the like.

HENRI C. SEIBERT

ANIMAL MORPHOLOGY

BUCHANAN'S MANUAL OF ANATOMY. *Seventh Edition. Edited by F. Wood Jones; Assisted by E. L. Patterson,*

S. Mottershead, T. E. Barlow, F. R. Wilde and Jessie Dobson. A William Wood Book, The Williams & Wilkins Company, Baltimore. $10.00. viii + 1616 pp. + 49 plates; text ill. 1946.

The first edition of this anatomical treatise appeared in 1906 and was written by A. M. Buchanan, Professor of Anatomy in Anderson's College, Glasgow. It was designed as "a guide to the structure of the human body as it is revealed in the process of dissection" and was a topographic, rather than a systematic textbook, a distinction which is no longer consistently applied in the last edition. The latter has been greatly revised and brought up to date by F. Wood Jones, with the assistance of five of his colleagues from the University of Manchester. The original plan of Buchanan's fine old work has been retained wherever possible. Nearly all of the clear drawings by J. T. Murray for the first edition, extensively deleted and substituted in later issues, have been restored, and over 200 new illustrations have been added, among which a series of splendid x-ray plates are especially noteworthy. The scattered embryological notes of former editions have been largely replaced by a new, concentrated chapter on growth and development. The nearly 300 pages of osteology form an unusually large part of this supposedly topographic manual, but this, really systematic, part contains much interesting information, rarely found in other textbooks.

With 847 textfigures, 48 plates, an extensive glossary, and a list of biographical data, this well-written and clearly printed volume deserves to be recommended to medical students as a useful addition to, though not a substitute for, a systematic textbook of human anatomy.

A. H. Schultz

Bone and Bones: *Fundamentals of Bone Biology. By Joseph P. Weinmann and Harry Sicher. The C. V. Mosby Company, St. Louis.* $10.00. 464 pp.; ill. 1947.

This book, by a pathologist and an anatomist, attempts to summarize our knowledge of bone as tissue, and of bones as organs. It is a compilation of a considerable part of the vast accumulated information on bone derived from clinical, microscopic, roentgenological, chemical, and experimental studies. The volume is very instructive and reliable as far as it has covered the ground, but it represents the broad title only in an incomplete fashion. The account of the "normal structure and growth of bone and bones" is limited to 104 pages, whereas the "pathology of bone and bones" occupies 299 pages. The chapter devoted to normal bones would have benefited by a consideration of the most significant results from investigations in embryology and comparative anatomy. The generous list of references is useful even though it includes mostly papers in English, only random samples of the German literature, and extremely few titles in other languages. The book is well printed, including most of its 289 illustrations.

A. H. Schultz

The Brain of the Tiger Salamander *Ambystoma tigrinum.*

By C. Judson Herrick. The University of Chicago Press, Chicago. $5.00. viii + 409 pp. + 1 plate; text ill. 1948.

This book is notable in the history of neurology. In my opinion no other animal except the human has had as complete a coverage of its nervous system as given in this treatise. The uniqueness of the book and its greatness lie in the fact that most of its information is the fruit of more than fifty years of intensive study by one individual whose ability to synthesize pertinent facts is recognized by all. *Ambystoma* was an ideal choice. The great change that occurred in the vertebrate organism from an aquatic existence to a terrestrial one where locomotion radically modified structures is reflected in its nervous system.

In seeking the origin of the cerebral cortex, Professor Herrick found in *Ambystoma* the segment in phylogenetic history which has produced "pay dirt." This comprehensive enterprise, in conjunction with the Coghill program, has placed in the hands of neurologists and physiologists valuable and necessary information, which, with modern technics, will aid in understanding the basic morphologic and behavioral patterns.

The book is divided into two sections. The first part of 122 pages deals with general principles of structure and function of a primitive nervous system, with valuable suggestions regarding higher forms. The chapter on general principles of morphogenesis is as clear a statement regarding morphogenic agencies as the writer has found anywhere. There appear throughout this first part philosophical statements which lend encouragement and enthusiasm for any scientific endeavor. The last sentence in this section reads in part, "... the humanistic values of science must always be acknowledged and cultivated." At the end of the chapter on The Origin and Significance of the Cerebral Cortex, a meaningful statement appears: "Obviously, conventional methods of inquiry must be pushed to the limit of their availability, and in the meantime new formulations of problems must be sought with all the resourcefulness that scientific imagination can command, not neglecting the possibility that some of these formulations may lie outside the frame of current Newtonian and quantum mechanics."

This general description and interpretation will be

of considerable value to neurologists, psychiatrists, physiologists, and others interested in development and behavior. Comparative neurology is no longer an isolated specialty, because it now has the active cooperation of all fields of medicine. This means that the investigation of these specialists may now be synthesized and given meaning. Professor Herrick's book will serve as a guide for such advanced research. He has brought before an interested audience of biologists and medical men the fruit of a long lifetime of endeavor in what appears a very restricted area; but in his hands it is presented in its true light, namely, the genesis of the vertebrate nervous system. From this study, one is helped to comprehend with understanding the complicated nervous system of man.

The second part of 300 pages is restricted to the specialist in comparative neurology and the physiological experimentalist. The material is compiled from previous papers but organized into a unity, namely, the total picture of the neurology of the *Ambystoma* brain. New material has been added. An extensive bibliography which includes pertinent papers for further references brings together most of the material in this field. There are 113 illustrations of the Gross and Microscopic Anatomy as well as the neurological aspects of the salamander brain. With this wealth of accurately described nervous tissue, the salamander may well supplant the frog as an experimental animal.

PAUL G. ROOFE

ANIMAL GROWTH AND DEVELOPMENT

UNE THÉORIE DU CHAMP BIOLOGIQUE CELLULAIRE. *Series D, Bibliotheca Biotheoretica, Volume II.*

By Alexandre Gurwitsch. E. J. Brill, Leiden. 9.00 guilders (paper). 149 pp.; ill. 1947.

This small monograph is divided into two portions. The first, which is the shorter, is devoted to an epistemological analysis of method in biological science. The second presents the theory of a biological field which the author considers a fundamental principle to aid our efforts to comprehend the phenomena of life. The introductory philosophical section represents a modern, logically clear, and sophisticated analysis of a problem which is the basic interest of biologists, and should prove stimulating to those who wish to think this problem through to its depths. The second section, which is the principal part of the book, derives the concept of a cellular field, anisotropic in nature, and acting upon certain molecules which are endowed with excess energy in such a way that the surplus is transformed to kinetic energy. The action of the field can then be defined in terms of vectors; and various phenomena of development, of heredity, of metabolism, of nervous activity, are explained in the terms of such fields. The author relates the origin of the cellular field to the chromatin. He considers not only th his theory can deal with the data of genetics, but tha the classical theory of the gene is inadequate to do so

Much of the factual evidence on which Gurwitsch bases his theory stems from his acceptance of the validity of the demonstration of mitogenetic rays, and discussion will therefore be of primary interest to those who agree with his interpretations in this controversial matter. All biologists are obviously at perfect liberty to agree, or to disagree, on this subject with Gurwitsch or with any other investigator. Since the issue remains open, however, Gurwitsch might have done well at least to mention, either in text or bibliography, the work of Hollaender, if only for the sake of completeness.

On the technical side, it may be said that the legends for the diagrams are too brief to be adequate and that there are many typographical errors. The book is written in lucid and interesting French. There are many of us, who know no Russian, who would be very pleased if more scientific articles from Moscow were available to us in French.

JANE OPPENHEIMER

THE CIRCULATION IN THE FOETUS. *A Synopsis for Students.*

By Kenneth J. Franklin, Alfred E. Barclay, and Marjorie M. L. Prichard. Blackwell Scientific Publications, Oxford. 2s. 6d. (paper). iv + 28 pp ill. 1946.

In 1944, these same authors published a notable monograph carrying the same title. That volume was characterized by systematic treatment of the subject, and included an unusual historical survey and a detailed report of the authors' own investigations on the fetal circulation in the goat. Excellent use of cineradiography was employed in the analysis of the flow of blood into, through, and from the heart prior to and after closure of the ductus arteriosus. This synopsis of that publication has been published in response to a manifest need for it.

One of the student associates in research of the authors suggested to the editor of the *Kings College Hospital Gazette* that a short account of the fetal circulation be published in that journal, for the use of medical and veterinary students and nurses in training. There was an immediate demand for reprints which only a separate publication could supply. This pamphlet, written by Franklin, late dean of the Medical School at Oxford University, is the result. It contains the essential story of the fetal circulation at the time of birth, including a historical survey, an account of the present state of knowledge to which these authors have contributed so importantly, and an estimate of the prospects which lie ahead in this field of investigation. Included are thirteen halftone and

ecut illustrations selected from the original monoaph for their clearness and value in pointing up the rt.

This little publication should serve well its intended urpose. It is brief, clear, comprehensive, and well orth the price, equivalent to fifty cents in American oney. American publishers might well see in this ype of publication a means of enlarging the usefulness nd extending the audience of many specialized onographs which normally reach but a small number f individuals.

S. R. M. REYNOLDS

ANIMAL PHYSIOLOGY

TEXTBOOK OF PHYSIOLOGY. *Ninth Edition.* *By William D. Zoethout and W. W. Tuttle. The C. V. Mosby Company, St. Louis.* $4.75. 723 pp. + 6 plates; text ill. 1946.

his book is intended to fill the gap between the larger xtbooks of physiology and the elementary ones. uch an intermediate position is difficult to attain ithout losing the virtues of the extremes, but the uthors have been quite successful in their undertaking. In some sections, as in the chapters dealing ith peripheral nerve and muscle function, it seems at the space allotted has been devoted merely to finitions and vocabulary, and that little has been aid regarding the basic mechanism of function. In any instances, however, the treatment is good, and ll the information is given that students of dentistry, harmacy, or those attending normal schools are xpected to retain. The scope of the book is broad. believe a greater depth of treatment could have been ttained had some of the space now devoted to antomical and biochemical matters been employed therwise. On the other hand, many of the emphases re rather nicely calculated to meet the requirements f that group for which the book was written.

CHANDLER MCC. BROOKS

ON THE CONTRIBUTION OF CLINICAL STUDY TO THE PHYSIOLOGY OF THE CEREBRAL MOTOR CORTEX. *The Victor Horsley Memorial Lecture, Delivered at the National Hospital, Queen Square, November 27, 1946.* *By F. M. R. Walshe. E. & S. Livingstone, Edinburgh; The Williams & Wilkins Company, Baltimore.* 50 cents (paper). 32 pp. 1947.

his lecture is devoted to a commendation of various oncepts which had their origin in clinical investiation, and to a criticism of those physiologists who peak of the cortical representation of anatomical lements of the body. By ascribing to these experimental physiologists ideas which are absurdly simple and which they do not hold, the lecturer endeavors to make a case for the cortical representation of "movements" instead of "muscles." He states: "In short, the notion of a cortical representation of structure as such, whether a muscle or a dermatome, is an ontological absurdity." He does not seem to feel that it is at all absurd to think of movements without muscles. It seems to me that the author could have produced something much more worthy of attention had he taken time to realize that the concepts of these individuals whom he criticizes are not vastly different from his own. A better lecture would have resulted had he devoted his considerable ability to a consideration of the mechanisms whereby the cortical representations of anatomical units are so interrelated or interconnected in their activity that patterns of reactions occur rather than the isolated uncoordinated responses of units when the cortex is excited. The author speaks of cortical representation as being in perpetual flux. Experimental physiologists can certainly agree with that, as he later defines it; but they cannot agree that all portions of the cortex are equally important to all functions. This flux has its anatomical and physiological limits, and the author probably does not mean to imply that it is otherwise. The reviewer does not wish to detract from the glory of those praised nor does he wish to minimize the importance of the idea that the body reacts as a whole and that reactions are of an extensive, coordinated nature. Nevertheless, it should be stated that the work of the experimental physiologists has been summarized in such a completely inadequate and unsympathetic manner that the lecture is not very satisfying.

CHANDLER MCC. BROOKS

LA CHALEUR ANIMALE. *"Que Sais-Je?" Le Point Des Connaissances Actuelles, Number 205.* *By André Missenard. Presses Universitaires de France, Paris.* 75 fr. (paper). 128 pp.; ill. 1946.

This small volume is subdivided into four parts. The first deals with the maintenance of a uniform body temperature, the second part with the sensation of heat and its influence on human activity, the third with the general influence of environmental temperature on the health and behavior of homotherms, and the fourth part is devoted to climatic considerations. Each of these sections consists of a few short chapters which deal very succinctly with the variations of body temperature upon exposure to heat and cold, acclimatization, resistance to environmental extremes, temperature and human comfort, mechanisms of heat loss and retention, artificial regulation of temperature and civilization, the geographic limits of desirable climatic conditions, temperature as an economic factor,

and many other topics. It is indeed a very interesting little treatise, containing much useful information.

CHANDLER McC. BROOKS

TEXTBOOK OF ENDOCRINOLOGY.

By Hans Selye, with a Preface by Bernardo A. Houssay. Acta Endocrinologica, Université de Montréal, Montréal. $12.80. xxxii + 914 pp.; ill. 1947.

Hans Selye has attempted to summarize our present knowledge of the endocrines in a textbook, profusely illustrated and highly informative, which gives an excellent over-all picture of the physiology, pharmacology, and pathology of the endocrine glands. As Professor Houssay states in the preface: "In addition to being a text, the book is also an atlas since it contains illustrations of everything that can be photographed (histology, crystals of hormones, experiments, X-rays of clinical cases)." The illustrative material is well chosen and superbly reproduced. The main facts and theories of endocrinology are presented in a well organized fashion, and most of the chapters will prove to be a valuable guide both for the beginner and the advanced student. In other chapters, however, this reviewer has found some quite misleading inaccuracies. For instance, Selye states: "It appears that the testes of the Sebright (and of similar breeds) normally produce folliculoids which cause hen-feathering" (p. 621). This assumption is not in agreement with the experimental findings that a castrated Sebright male having acquired cock plumage becomes hen-feathered under the influence of an implanted Leghorn testis, and that the male plumage of a Brown Leghorn does not become hen-feathered under the influence of a grafted Sebright testis. These results rule out the production of estrogens (folliculoids in Selye's terminology) and indicate that the difference in the plumage is merely due to a difference in reactivity of the feather germ in the two races. It is this difference in the reaction of the end organ which led Fuller Albright to introduce the term "Sebright bantam syndrome" for a disease with a curious deficiency of end-organ response, pseudo-hyperparathyroidism. Selye has missed this concept entirely and in discussing patients suffering from pseudo-hypoparathyroidism he states: "Because of their peculiar appearance (round face, rather thickset figure), the term 'Sebright bantam syndrome' was chosen to describe them" (p. 569). Does the author imply that patients suffering from hypoparathyroidism resemble the Sebright bantam breed of fowl in outward appearance?

The discussion of hypothyroidism in children is hardly adequate. No mention is made of the fact that the cretin is not only stunted in height, but that body proportions remain infantile. In discussing the X-ray signs of cretinism, mention is made of the delayed appearance of the centers of ossification, but not of the diagnostically important epiphysial dysgenesis. Furthermore, Selye claims that in children suffering from hypothyroidism the daily dose of desiccated thyroid should be raised from 0.1 grain at 6 months to 1 grain at puberty. Most clinicians who have had some experience in the management of hypothyroid children find this dosage wholly inadequate.

It is not the intention to point out every minor error in an otherwise excellent book. The references given are few, but well chosen. They include books and papers written in the English, French, Dutch, Spanish, Portuguese, and German languages. Much thought and labor has gone into the preparation of the index. Under the author's name we find the entry: "see: what next?" Under "what next" appears the entry: "see: Selye." This reviewer hopes that what next will be a carefully revised second edition of this splendid book.

WALTER FLEISCHMANN

A CONTRIBUTION TO THE KNOWLEDGE OF THE INFLUENCES OF GONADOTROPIC AND SEX HORMONES ON THE GONADS OF RATS. *Monographs on the Progress of Research in Holland During the War.*

By J. H. Gaarenstroom and S. E. De Jongh. Elsevier Publishing Company, New York, Amsterdam. $3.00 (paper). viii + 164 pp. + 8 plates. 1946.

This is one of a series of twenty-four monographs, so far announced, dealing with Netherlands wartime scientific work. It is an attractive, pocket-sized booklet that includes twenty pages of abstracts of endocrinological interest for the period 1940–44, which is represented largely by gaps on the library shelves. The main part of the volume is given over to a description of very numerous experiments bearing on the subject matter of the title, in which the authors have rather more scope than is usually available in scientific papers for discussion and theorizing. Their main contention is that the action of gonadotrophic hormones on the testis is, in part at least, mediated by the male sex hormone, testosterone, acting locally on the tubular apparatus. Work appearing concurrently in this country would appear to have supported this idea, and local effects of androgens on the testis have now been demonstrated for several species, including the primate *M. rhesus*.

The authors have extended their thesis to the ovary, where the case for a favorable effect of estrogenic hormones on follicular development is admittedly more speculative. Those interested in this field should be able to follow the authors' close reasoning with pleasure and profit. Die-hard advocates of a single pituitary gonadotrophin are moreover confounded by a "seem-

ingly irrefutable proof" of the existence of two. A further favorable word should be said for this type of unpretentious and presumably inexpensive publication for the dissemination of ideas.

H. R. CATCHPOLE

LE SEL EN BIOLOGIE. *Étude d'Ensemble sur le Chlorure de Sodium en Physiologie et en Pathologie.*

By P. Louyot, préface by Professeur Loeper. Masson et Cie., Paris. 500 fr. (paper). iv + 254 pp.; ill. 1947.

This book on salts, especially sodium chloride, deals with the physiological and pathological aspects of these substances in the human body. It is a non-technical text written in an elementary style. It contains the names of many workers, but the bibliography is relatively small for so large a subject (some three hundred references).

The scope of the book is indicated by the four main sections into which the text is divided. Part One is concerned with the occurrence of salt in blood, tissues, and body fluids during health. Absorption, transportation, partition, and elimination of salt are likewise discussed. Part Two is concerned with the fate of salt in various pathological states. Conditions discussed are: (1) faulty renal elimination (nephritis, Addison's disease, diabetes insipidus, and diabetes mellitus); (2) excessive loss by routes other than the kidney (vomiting, diarrhea, sweating, ascites, and so forth); and (3) dysfunctions of movement and partitioning of salt in the body (infections, shock, edema, neurogenic and endocrine factors, and other diverse conditions). The third part of this volume is concerned with concepts of pathogenicity of salt metabolism. The fourth part gives the author's estimate of therapeutic rationales whereby dechlorination and rechlorination may be accomplished.

It would seem that this volume would be of most value to clinicians who desire a comprehensive review of a large and important subject and a current survey of up-to-date viewpoints. Being written in French, it will of necessity be useful primarily to physicians in French-speaking countries.

S. R. M. REYNOLDS

CURARE: *Its History, Nature, and Clinical Use.*

By A. R. McIntyre. The University of Chicago Press, Chicago. $5.00. viii + 240 pp. + 1 plate; text ill. 1947.

The first four chapters of this book deal with the discovery and the early history of the study of this famous South American arrow poison and are most interesting and instructive. The work done upon the botanical identification of the curare plants is likewise well described. Chapter five, which describes the chemical studies aimed at identifiying the chemical nature of the poison, is quite adequate. It is only when one reads the chapters dealing with the effects of the curare drugs on function of nerve, muscle, circulation, respiration, and viscera that an impression of inconclusiveness is obtained. It is quite probable that much of the work has been inconclusive and contradictory, but the author has contributed no synthesizing ideas to help to bring clarity out of chaos. Chapters and topics are clearly summarized, but more could have been done to clarify the present state of knowledge about the effect of curare on the nerve muscle junction, because much excellent work has been done recently on the physiology of the end plate and the effect of curare on the end plate potentials. Several important papers dealing with this subject were not referred to. One infers, from the references given, that not much work has been done during the last ten years in several of the surveyed fields. The discussions of certain miscellaneous effects of curare and particularly the effects on the central nervous system are interesting and suggest new work that should be done. The chapter which deals with the clinical use of curare is well written and adequate. On the whole, this book is a valuable contribution and will serve well as a reference work. It should stimulate and aid future investigations.

CHANDLER MCC. BROOKS

DETOXICATION MECHANISMS. *The Metabolism of Drugs and Allied Organic Compounds.*

By R. Tecwyn Williams. John Wiley and Sons, New York. $5.50. viii + 288 pp.; ill. 1947.

The object of the author has been to gather together in this book, in orderly fashion, the available information on the metabolic fate of organic compounds foreign to the body. The ultimate aim of such a review would be to provide working hypotheses that may serve as guides for subsequent studies. A comprehensive summary of the subject matter is presented in the opening chapter, and certain theoretical considerations and conclusions are made in the final chapter of the text.

The subject is approached in methodical fashion, beginning with the metabolism of the aliphatic compounds, followed by that of aromatic hydrocarbons and halogenated derivatives. Subsequent chapters are concerned with the metabolism of: phenols; aromatic alcohols, ethers, aldehydes, ketones, and amides; aromatic acids; organic cyanides; aromatic nitro, amino, and azo compounds; sulphones, sulphonic acids, and sulphonamides; terpenes and camphors; heterocyclic compounds and the organic compounds of arsenic.

The biochemical changes that have become known

as detoxication mechanisms are essentially metabolic in character. The term is not entirely satisfactory. It implies a decreased toxicity of a particular substance upon metabolism in the animal body. This is not always the case, as in fact some compounds are rendered more toxic upon metabolic breakdown. The author suggests the use of the terms "hypertoxic," "isotoxic," and "hypotoxic," whenever it would be advantageous to do so. A cursory review of a number of current pharmacology textbooks indicates that the term detoxication is not frequently employed. *Chemical Abstracts*, however, includes in the index a listing of compounds under this heading.

The book may be useful to investigators interested in the toxicity of medicinally important compounds. It is quite clear, however, that the accumulated knowledge permits only very broad generalizations to be drawn regarding the metabolic fate of most foreign organic compounds in the animal body.

C. JELLEFF CARR

OUT OF THIS WORLD. *Anesthetics and What They Do To You.*

By Sylvan M. Shane. Creative Age Press, New York. $2.00. xvi + 111 pp. + 4 plates. 1947.

The author has made an effort to present to the layman the phenomenon of anesthesia in a style that will engross his attention. The book is written in the form of a story. It depicts the average man going into the hospital for a surgical operation. It describes his fears and points out the important role that the anesthesiologist plays in the obtunding of pain and the safeguarding of the life of the patient.

The various types of anesthesia, such as intravenous pentothal, cyclopropane, and ether-oxygen, are briefly described. The chapter entitled The Silver Cord Is Severed describes the production of spinal anesthesia. The third part of the book discusses the romance of anesthesia, beginning a century ago, and listing the important events in a summarized form up to the year 1946.

The book is intended primarily for the layman. Its style is lucid, and it appears to be a useful volume for allaying the fears of the layman with regard to anesthesia, and inspiring his confidence in the science and art of anesthesiology.

JOHN C. KRANTZ, JR.

THE RH FACTOR IN THE CLINIC AND THE LABORATORY. *Special Issue Number 2 of Blood, The Journal of Hematology.*

By Joseph M. Hill and William Dameshek. Grune and Stratton, New York. $4.25. viii + 192 pp.; ill. 1948.

This special issue, in a permanent binding, contains the papers presented at the International Hematology and Rh Conference held in Dallas and Mexico City in November, 1946. The contents are as follows: Preface (W. Dameshek); A Survey of the Significance of the Rh Factor (P. Levine); The Rh Genotypes and Fisher's Theory (R. R. Race); Hemolytic Mechanisms (W. Dameshek); Generalities on the Nucleolar Content of Some Blood Cells (I. G. Guzmán); Interrelationship between the Rh System and the A B System (E. Witebsky); Hemolytic Rh Immune Globulins: Evidence for a Possible Third Order of Antibodies Incapable of Agglutination or Blocking (J. M. Hill, S. Haberman, and F. Jones); Acute Renal Insufficiency Due to Incompatible Transfusion and Other Causes, with Particular Emphasis on Management (E. E. Muirhead, A. E. Haley, S. Haberman, and J. M. Hill); Rh Antibodies; Correlation with Clinical Findings (I. Davidsohn); On Certain Variations in Erythroblastosis Fetalis (B. Chown); The A and B Factors as a Possible Cause of Erythroblastosis (A. C. V. Orozco); The Treatment of Erythroblastosis Fetalis by Substitution Transfusion (H. Wallerstein); Current Problems Regarding the Rh Factor (general discussion); Historical Review of Mexican Blood Transfusion (E. U. Guerola). The volume has an index.

This volume will be an essential reference for hematologists, immunologists, and geneticists studying man. The publishers are to be thanked for providing the special issue in so substantial and attractive a format.

BENTLEY GLASS

STUDIES ON CARBOHYDRATE AND FAT METABOLISM. *With Especial Reference to the Pigeon. Carnegie Institution of Washington Publication 569.*

By Oscar Riddle and associates. Carnegie Institution of Washington, Washington, D. C. $2.25 (cloth); $1.85 (paper). vi + 128 pp. 1947.

This is an account of the specialized researches of the Cold Spring (Carnegie) group on other phases of pigeon physiology and endocrinology. Briefly summarized are some of the differences between avian and mammal.

H. R. CATCHPOLE

ENDOCRINES AND CONSTITUTION *in Doves and Pigeons. Carnegie Institution of Washington Publication 572.*

By Oscar Riddle. Carnegie Institution of Washington Washington, D. C. $4.00 (cloth); $3.00 (paper). xii + 306 pp. + 1 plate; ill. 1947.

The author's name will be associated with numerous papers on the physiology and endocrinology of these avian forms, that have appeared during the past years. The present volume represents the results of a 24 year study. Briefly, the first half of the book describes methods used to segregate certain constitutional factors having relation to the endocrines; e.g., responses to prolactin, testis weight, egg weight, etc. In this way a series of "physiological races" was built up. In the second part, the effect of race, sex, age, etc., on basal heat production was dealt with. Each of the 18 chapters consists of detailed presentation of graphs and tables, and each carries an introduction and a short summary. Readers interested in these various phases will probably find it convenient to dig into the pertinent sections piecemeal, since a general synthesis was not made and was hardly to be expected. A concluding statement points to the marked biological inequality of the dove races developed in this programme. The author sees evidence in this for the idea of a genetical and biological inequality of human individuals, types, and races supported by "a few anthropologists."

H. R. CATCHPOLE

ANIMAL NUTRITION

PROTEINS AND AMINO ACIDS IN NUTRITION. *Edited by Melville Sahyun. Reinhold Publishing Corporation, New York City.* $7.50. xvi + 566 pp.; ill. 1948.

The editor and seventeen outstanding authorities in special fields have prepared the fifteen chapters of this timely book. The Introduction is by H. B. Lewis. Succeeding chapters are: Proteins in Nutrition (Historical) (E. F. Beach); The Biological Utilization of Proteins and Protein Requirements (H. H. Mitchell); Caloric, Vitamin and Mineral Requirements with Special Reference to Protein Nutrition (H. J. Deuel, Jr.); Economic Aspects of Food Proteins (L. E. Booher); The Nutritive Aspects of Meat and Meat Products (H. R. Kraybill); The Amino Acid Requirements of Avian Species (H. J. Almquist); The Relation of Hormone to Protein Metabolism (A. White); Plasma Proteins and Their Relation to Nutrition (M. Sahyun); Protein Deficiency and Its Relationship to Nutritional Anemia, Hypoproteinemia, Nutritional Edema, and Resistance to Infection (C. P. Berg); Protein and Amino Acid Nutrition in Pediatrics and in Pregnancy (S. Z. Levine); Protein Nutrition in Surgical Patients (C. C. Lund and S. M. Levenson); The Relation of Fluid and Mineral Balance to Protein Metabolism (W. E. Abbott); Proteins as Related to Burns (A. Large and C. G. Johnston); The Protein Nature of Toxins, Antitoxins and Related Substances (E. A. Kabat); Protein Nature of Filterable Viruses (M. A. Lauffer). Appendix: Table 1, Proximate Composition of American Foodstuffs; Table 2, Nutritive Value of 100 Grams of Selected Foods, Edible Portion; Index.

This volume will be read with interest by biochemists, physiologists, teachers of nutrition, and members of the medical profession. It is an excellent and authoritative work.

E. V. MCCOLLUM

LE DOSAGE MICROBIOLOGIQUE DES VITAMINES. *Médecine et Biologie, Number 1.*

By Maurice Welsch; edited by Marcel Florkin. Editions Desoer, Liège. 100 fr. (paper). 193 pp. 1947.

This small volume presents a selection of the best known procedures for the microbiological assay of thiamin, riboflavin, nicotinic acid, pantothenic acid, pyridoxine, biotin, folic acid, i-inositol, and p-aminobenzoic acid. There are taxonomic and alphabetical indexes. This book is not likely to be of much service to those engaged in the assay of vitamin preparations because there are now available far more comprehensive and critical books which cover this field of inquiry. There is an insert page which calls attention to errors of typography on twenty pages. There is a short bibliography at the end of each chapter.

E. V. MCCOLLUM

ESTIMATION OF THE VITAMINS. *Biological Symposia, Volume XII.*

Edited by W. J. Dann and G. Howard Satterfield. The Jaques Cattell Press, Lancaster, Pennsylvania; The Ronald Press Company, New York City. $6.50. x + 531 pp.; ill. 1947.

This volume contains twenty-nine chapters, each written by one or two persons who have studied critically the methods which they discuss. Methods based upon physical and chemical, biological and microbiological technics are described and appraised on the basis of the experience of the contributors and the recorded experience of others.

The fifteen best characterized vitamins are discussed in the volume. Anyone who studies this book will find the recommended method for assay of each vitamin, a critical discussion of the details involved, and conclusions as to its merits and limitations.

It is not apparent to the reviewer how the subjects could have been treated more effectively to improve the usefulness of the book. Everyone who is engaged in any way in work with vitamins will find it a source of reliable information on almost any question likely to

arise in the present state of knowledge. It should find wide acceptance.

E. V. McCollum

LITERATURE SEARCH ON THE PRESERVATION OF FOODS BY FREEZING. *First Supplement, January, 1946–July, 1947. Special Report Number 25.*

By Betty Anderson and B. H. Weil. State Engineering Experiment Station, Georgia School of Technology, Atlanta. $3.00 (paper). viii + Pp. 407–670. 1948.

BIOCHEMISTRY

LES INOSITOLS. *Chimie et Biochimie.*

By Paul Fleury and Paul Balatre. Masson et Cie., Paris. 300 fr. (paper). ii + 166 pp. 1947.

In this useful volume the authors have compiled and discussed the experimental data to be found in the original literature upon every aspect of the chemistry and biochemistry of i-inositol and its isomers. All of the facts available relating to the physical properties of the ten isomers of 1,2,3,4,5,6-cyclohexane-hexol, their synthesis, and degradation are recorded. The naturally occurring derivatives of i-inositol are also described. There are separate chapters on the significance of this substance and its derivatives in the plant and animal kingdoms. The literature on the bacterial and animal metabolism of i-inositol is discussed. There is a bibliography of 419 titles. This small volume will be welcomed by investigators in plant and animal physiology, bacteriologists, and biochemists.

E. V. McCollum

THE SULFONAMIDES AND ALLIED COMPOUNDS. *American Chemical Society Monograph Series.*

By Elmore H. Northey. Reinhold Publishing Corporation, New York. $12.50. xxviii + 660 pp. 1948.

This monograph has required years to write. It is an outgrowth of previous reviews by the author published in 1939 and 1940. An attempt has been made by Northey to cover adequately the chemical side of sulfonamide chemotherapy. As pointed out in the preface, "progress has been so rapid and the number of new compounds synthesized so great, now over 5000, that it has been all but impossible for chemists active in the field to keep up with developments." The author's aim has been also to provide pharmacologists and clinicians with data on the activities and important properties of these drugs. A further aim has been to provide research workers in general with a brief summary of the medicinal uses and limitations of those sulfonamides that have come to clinical trial. The value of such information lies in the suggestions that may be prompted thereby for new compounds of still greater merit.

The status of sulfonamide therapy is sharply revealed by the figures cited by Northey on sulfonamide drug production in the United States in 1943, when over 10 million pounds of these compounds were manufactured. It is estimated that this figure (representing a war year) is now considerably reduced, owing in part to the advent of antibiotic therapy.

It would be unfair to prospective users of this volume to cite Northey's dramatic illustrations of the accomplishments of sulfonamide chemotherapy in acute infectious diseases. The reader may enjoy these for himself. The author's contribution, along with that of those whose names are listed in the bibliography, will serve as a monument to their memory.

A list of monographs and reviews concerned with the medical literature of sulfonamide chemotherapy published prior to and during 1944 is given in the preface. Over 2600 references (largely chemical) to the literature are cited in the bibliography. A list of 39 of the more important journals that have been searched—through 1944—is given in the back of the volume. In the appendices a rather complete key to organisms and diseases is set forth. Trade names for sulfanilamide (sixty in number) and the trade names for the other sulfonamides are also provided in tabular form.

In this undertaking the author has been assisted by Dr. Harold J. White, who wrote the chapter on the measurement of chemotherapeutic activity, and Dr. J. T. Litchfield, Jr., who wrote the chapter on the pharmacology of the sulfonamides and sulfone drugs. Dr. Benjamin W. Carey is given the responsibility for the chapter on the clinical evaluation of sulfonamide drugs.

The book is divided into twelve chapters. A historical review of the subject is presented in one chapter. The major portion of the text is devoted to the nomenclature, classification, synthesis, structure and activity of the sulfonamides and sulfones. The chapters concerned with the experimental evaluation and pharmacology of these drugs will be most valuable to workers in this field. The sections devoted to the relationship of structure to chemotherapeutic activity and theories of the mechanism of action of sulfonamide drugs will be useful reference sources for students of the subject.

In the opinion of the reviewer this monograph is a monumental work; replete as it is with tabular material from so many sources, it should serve well to provide the synthetic organic chemist, the bacteriologist, the

pharmacologist and the worker in the field of experimental therapeutics with a comprehensive reference source.

C. JELLEFF CARR

MICROBIOLOGY

BERGEY'S MANUAL OF DETERMINATIVE BACTERIOLOGY. *Sixth Edition.*

By Robert S. Breed, E. G. D. Murray and A. Parker Hitchens. The Williams & Wilkins Company, Baltimore. $15.00. xvi + 1529 pp. 1948.

Since all other treatises on bacterial systematics are now too old to be used for determinative purposes, *Bergey's Manual* has become an indispensable work of bacteriological reference. It is accordingly gratifying to discover that the present version, although not without blemishes, constitutes an enormous improvement in many respects over previous editions.

Considerable changes have been made in the main outlines of classification. Some of them reflect a clearer perception of natural relationships, the most notable instance being the abandonment of the artificial order *Thiobacteriales* and the redistribution of the very heterogeneous assemblage of organisms previously included therein, an approach which has made it possible to place the photosynthetic bacteria in the *Eubacteriales* along with their colorless morphological counterparts. Such steps in the direction of establishing natural major groups have been accompanied by a significant innovation: the liberal use of supplements and appendices in cases where genera and families whose relationships are unknown or uncertain can be described without being assigned to a definite position in the system as a whole. Considering our relative ignorance of bacterial phylogeny, this modest and tentative approach to the thornier problems of the subject contrasts favorably with the practice in earlier editions, where virtually all known bacteria were forced (often by somewhat Procrustean methods) into a rigid taxonomic framework. The use of supplements and appendices in this manner serves a valuable purpose by emphasizing taxonomic regions that are still terra incognita, but at the same time it brings in its train determinative problems which have not been satisfactorily solved in the present volume. When a substantial percentage of the bacteria are provisionally located, it is essential that an adequate system of determinative keys be provided. This the editors have failed to do. There are many organisms which cannot be tracked down by following the keys and whose discovery requires either intuition or a thorough knowledge of the *Manual* as a whole. The index of sources and habitats that has been added to the present edition should be of some help in locating unkeyed groups, but it is by no means an adequate substitute for a system of multiple keys. This is a deficiency that should be easily remedied in the future.

One novelty of which this reviewer heartily disapproves is the appearance (though admittedly in the shy seclusion of a supplement) of a new order *Virales*, subdivided into families, genera, and species, all provided with Latin designations according to the accepted rules of taxonomy. This implies a far more definite understanding of the origin and nature of viruses than most workers with these entities would be willing at present to concede, and its determinative utility is far from evident. In any case, the *Manual* is alleged to be a treatise on determinative *bacteriology*, and is thus hardly the most suitable vehicle for this curious taxonomic exercise, unless the editors plan an extension of the class *Schizomycetes* to include acellular entities.

In the treatment of many individual genera and families there have been marked improvements, reflecting the success of the editors in obtaining the services of specialists for this revision. As shown by the lengthy list of contributors appended to the title page, the *Manual* has now become a truly coöperative venture; although the taxonomic skeleton remains a matter for editorial decision, the detailed systematic presentations that clothe it are the work of many. Not the least valuable parts of these contributions are the explanatory essays that accompany some of them. The reviewer particularly enjoyed F. Smith's account of the problem of speciation in the genus *Salmonella* and van Niel's lucid analysis of the confused taxonomic history of the photosynthetic bacteria. The fine general introduction to the *Myxobacteriales*, prepared by Buchanan for the fifth edition, has been revised and extended. Similar introductions to the other orders would greatly enhance the value of future editions.

There still remain large sections whose treatment is inadequate, but in many cases (e.g., the families *Achromobacteriaceae* and *Bacteriaceae*) the trouble stems from a lack of information about the bacteria concerned. This excuse cannot be offered, however, for the family *Lactobacteriaceae*. As originally conceived by Orla-Jensen, it was one of the few really satisfactory larger assemblages of true bacteria, clearly defined on the basis of many common properties, both morphological and physiological. Its boundaries have now been extended to include a motley collection of genera and species having little in common either with the true lactic acid bacteria or with one another, and in some cases not according with the definition of the family, even though this has been revised to make it more widely inclusive. It is to be hoped that in the next edition the *Lactobacteriaceae* will be restored to its original form and the present strangers within its gates given other accommodation—in most cases, an easy task.

In spite of the criticisms offered above, it should be

recognized that the present revision of the *Manual* is a monumental achievement. Probably no bacteriologist will be wholly satisfied with it, but all will be grateful to the editors for the time and effort that they have put into this indispensable book.

R. Y. STANIER

ATLAS OF BACTERIOLOGY.

By R. Cranston Low and T. C. Dodds. The Williams & Wilkins Company, Baltimore. $8.50. viii + 105 pp.; ill. 1947.

This atlas, printed on luxurious paper, is mainly a collection of drawings of bacteria and bacterial cultures as the medical technologist sees them after standardized and often brutal treatments. The accuracy of reproduction is remarkable, the usefulness questionable when we realize that ability in practical laboratory diagnosis can only result from long practice on the part of the technician. The general practitioner will find this atlas useful in understanding the meaning of terms and descriptions used in textbooks of medical bacteriology and pathology.

As for the bearing of the illustrations of bacterial cells on bacterial cytology, the relation is about that of a photograph of a positive Fehling reaction in the test tube to the structural formula of glucose. It is actually this routine deformation of bacterial cells for the purpose of diagnosis that has been responsible for the regression of bacterial cytology dating from the middle of the 19th century until a few years ago. It is only thanks to the efforts and tenacity of a few almost ignored cytologists that bacteriologists are beginning to see now in bacteria about as much as Leeuwenhoek and de Bary used to see in their days. There is a crying need for a true bacterial cytology upon which to build a science of bacteria as living things.

S. E. LURIA

BACTERIOLOGY. *A Textbook of Microorganisms. Fourth Edition.*

By Fred Wilbur Tanner and Fred Wilbur Tanner, Jr. John Wiley & Sons, New York; Chapman & Hall, London. $4.50. x + 625 pp.; ill. 1948.

This textbook has some good features in comparison with other current textbooks of bacteriology. It contains much needed review chapters on cell structure, plant and animal biology, molds and yeasts. The chapter on protozoa is fully inadequate, even for an understanding of modern ideas on comparative metabolism. Beyond that, in dealing with bacteria, this book has little to offer besides the exasperating dullness and platitudes of most similar textbooks. Can it be that the crisis of bacteriological writing stems from the attitude of most bacteriologists toward bacteria? Zoologists and botanists, as a whole, are naturalists; that is, they love living things. Bacteriologists seem to suffer from a sort of ancestral hatred for bacteria, possibly rooted in the tradition of medical bacteriology. This seems particularly true of textbook writers; there is more feeling for bacteria in Rahn's popular *Microbes of Merit* than in any or all of five textbooks lying on this writer's desk.

The innumerable factual inaccuracies, mostly due to lack of critical revaluation of old data (see, for example, the paragraph on the chemical composition of bacterial capsules, p. 103), are secondary to the irrelevance and hearsay character of most of the information given. In a book with the subtitle: "Fundamental facts and principles for the first course in bacteriology," we find no mention of nucleoproteins, 19 lines on "Constitutive and Adaptive Enzymes," 8 lines on "Mutations," 26 lines on "Microbic Dissociation," and one and a half pages on "Cucumber pickles." Maybe what is wrong with too many bacteriologists is that they are not interested in "fundamentals," and are less fond of bacteria than of cucumber pickles.

S. E. LURIA

FUNDAMENTAL PRINCIPLES OF BACTERIOLOGY. *Third Edition.*

By A. J. Salle. McGraw-Hill Book Company, New York, Toronto, and London. $6.00. xii + 730 pp. + 1 plate; text ill. 1948.

The third edition of this standard text presents features which should make it of great value in certain respects. As mentioned on the dust jacket, it "emphasizes the importance of chemistry for a clearer understanding of the composition of bacteria and the reactions they produce."

The reviewer is in general agreement with this emphasis. The time has long passed when a bacteriologist could "get by" without a fundamental knowledge of chemistry, especially organic chemistry. It is perhaps a distortion to claim that bacteria are merely and solely "chemical machines," but so much of the activity of bacteria is chemical that a good grasp of chemistry is essential for the present-day bacteriologist, just as a solid knowledge of mathematics is essential for most forms of engineering.

Possibly the strong chemical emphasis of the book may even serve to limit its usefulness to some extent. At a rough guess, the chemistry involved would be about equal to that attained by a third year student of the chemical sciences. If this interpretation is approximately correct, then as a primary text the book would be appropriate mainly for chemists approaching bacteriology in their fourth year of college. However, it should be of immense value to graduate

bacteriologists who wish a better grasp of the fundamental chemistry of their science, and of supplementary value to those with lesser training in chemistry.

Some minor criticism of the chemical material is in order. The data on folic acid (p. 250) are 3 or 4 years out of date. It may be questioned whether formaldehyde (p. 210) acts as a germicide by reason of its reducing properties. More probably it acts by combining with proteins. The praise of sulfanilamide as a dusting powder for war wounds (p. 221) is outdated. Owing to caking of powdered sulfonamides, their local use in wounds caused much trouble in World War II. Accordingly, in the last stages of the war, their use by mouth was preferred.

Nevertheless, if the chemical parts of the book are generally deserving of high praise, the non-chemical material is almost equally praiseworthy in many cases. Thus, on p. 235, it is good to see a figure demonstrating the liquefaction of agar. Many students gain the impression that agar is *never* liquefied by bacteria. As an undergraduate, the reviewer even had a professor of bacteriology who held to this view rather violently. The photograph of air-borne droplets produced in blowing the last drop from a pipette (p. 465) may help to explain many laboratory infections occurring in handling highly infectious bacteria.

Even if the strong emphasis on the chemistry of bacteria should limit the usefulness of the book as a text for students, it should make it invaluable as a reference work for practising bacteriologists and others.

WALTER C. TOBIE

DAIRY BACTERIOLOGY. *Third Edition.* *By Bernard W. Hammer. John Wiley & Sons, New York; Chapman & Hall, London.* $6.00. x + 593 pp.; ill. 1948.

Workers on the bacteriology of milk and milk products will find that the third edition of this standard text contains a wealth of valuable information on the microbiology of dairy products. It is to a considerable extent a compendium of the literature to about 1946. This is supplemented by a critical discussion of the claims of various workers, and by general observations by the author. Abundant attention is paid to the biochemical as well as to the bacteriological aspects of the subject. Each chapter is followed by a large number of references, which will be of great usefulness to those who wish to go to primary sources of information. The work is one of the very best in its field and is to be highly recommended.

A few lesser criticisms may be justified. On p. 244, some mention might perhaps have been made of the efficacy of penicillin in the treatment of mastitis. Cysteine may inactivate penicillin (see p. 448), but cysteine would not ordinarily be called an enzyme.

WALTER C. TOBIE

PARASITOLOGY

TRICHOMONAS VAGINALIS AND TRICHOMONIASIS. *By Ray E. Trussell, with an introduction by E. D. Plass. Charles C. Thomas, Springfield.* $6.00. xii + 277 pp. + 1 plate; ill. 1947.

Trussell has rendered a valuable service to science by reviewing an extensive literature on the trichomonads of the human species. The bibliography of this monograph on the subject lists 1586 references which the author has apparently combed carefully for the essential information that has been included in this comprehensive compilation.

The author is excellently qualified to write a monograph of *Trichomonas vaginalis*, for it was he who first obtained a pure culture of this organism, thus initiating most of the fruitful recent discoveries concerned with its pathology and physiology. Working with able associates at the State University of Iowa, he has personally contributed much to our present knowledge of the growth requirements of the organism and the symptoms and treatment of vaginal trichomoniasis.

The book is divided into three major parts. The first, *Trichomonas vaginalis*, is devoted to the fundamental biology of this species and its relationships to other trichomonads. The second part, *Trichomonas vaginalis* Infections, presents the stricter medical phases of the subject. There are thorough discussions on the incidence of infection, methods of transmission, clinical symptoms, and laboratory diagnosis. Whereas formerly it was believed that transmission occurred mainly by inanimate objects, more recent information on the high incidence of the infection in men indicates a venereal transfer. The last portion of the book, on Treatment, is rather disheartening. The author reviews the various drugs and courses of treatment that have been tried, but concludes that there is no specific therapeutic agent which can at present be relied upon to cure latent and clinical infections of *Trichomonas vaginalis*.

It is fortunate that human trichomoniasis due to *Trichomonas vaginalis* is not as severe as the comparable disease in bovines. Nevertheless, due to its rather high nuisance value, this organism presents a challenge to the obstetrician, gynecologist, parasitologist, and those interested in preventive medicine. This excellent monograph will undoubtedly be a tremendous help to these scientists in their search for answers to the many unsolved problems.

The book possesses a detailed table of contents, an

index, many tables, several drawings and a number of photographs, two in full color.

M. M. BROOKE

HEALTH AND DISEASE

SCHOOL HEALTH AND HEALTH EDUCATION. *With Special Consideration of the Teachers' Part in the School Health Program.*

By C. E. Turner, with the Editorial Assistance of C. Morley Sellery. The C. V. Mosby Company, St. Louis. $3.50. 457 pp.; ill. 1947.

The broadening concept of health as something more basic and more important than the mere absence of disease has brought an increasing demand for formal health education at all scholastic levels. With the increased importance of public interest and participation in community public health efforts, sound courses in health education in the public schools are entirely justified.

The present volume encompasses the latest thinking and the most successful programs and techniques in the field of health education at the public school level. Written primarily for teachers and school health personnel either in training or in service, the work covers every aspect of the subject of health education, from the development of the school health program through the mechanics of its implementation down to an evaluation of its effectiveness. Special emphasis is given to the training and duties of health educators and school health workers.

The volume is carefully planned, clearly written, and well documented with a topical bibliography of more than 100 articles and books. An index is provided.

B. AUBREY SCHNEIDER

MEDICINE TODAY. *The March of Medicine, 1946. The New York Academy of Medicine. Columbia University Press, New York.* $2.00. xii + 177 pp. 1947.

In order to keep the general public abreast of the times and well informed on the progress of developments in the field of medicine, the New York Academy of Medicine sponsors an annual series of "Lectures to the Laity." The 1946 series, which comprises the present volume, was devoted to the social and economic aspects of medicine as related to the availability, cost, and distribution of medical care.

In the opening lecture, the development of organized medicine in the United States is summarized from the standpoint of the maintenance of high standards of medical training, practice, and research. The succeeding lectures cover such topics as the history of medical education, the evolution of the hospital and clinical laboratory, the relationships of the general practitioner to the specialist in providing adequate medical care, and the impact of medical research and technical advancements on the health problems of the world.

Perhaps the most pertinent lectures for lay consumption are the last two of the series, which deal with the role of the enlightened layman in the fields of preventive medicine, and group hospital and medical care. The best public health program in the world, including all the recent advances in sanitation, immunology, and epidemic disease control, is of no avail unless the general public understands the importance and the necessity of such a program. An enlightened public can do much to assist the medical profession in its never-ending struggle with quacks, nostrums, and anti-vivisectionists. The history of inadequate distribution of medical services in the past is leading rapidly to some sort of organized and integrated system of community health services. If the public is to secure comprehensive medical care of high quality by group medical practice and insurance type prepayment, as much intelligent thought and action will be required on the part of the layman as on that of the physician.

This volume provides for the layman a well balanced picture of the practice of medicine today, as well as the role of the public in an equable distribution of medical care. An index is provided.

B. AUBREY SCHNEIDER

THE BACKGROUND OF INFECTIOUS DISEASES IN MAN. *Lectures delivered in 1945 under the auspices of the Melbourne Permanent Postgraduate Committee and the New South Wales Postgraduate Committee in Medicine (University of Sydney).*

By F. M. Burnet. The Melbourne Permanent Postgraduate Committee, Melbourne, Australia. 7s. 6d. viii + 109 pp.; ill. 1946.

This little volume is the printed version of six lectures delivered in 1945. After an introductory lecture, the remaining five are devoted to: diphtheria, measles, rubella, and infectious jaundice; poliomyelitis; streptococcal infections with special reference to rheumatic fever; respiratory virus infections; and the natural history of tuberculosis. The material is presented in a sound and thoughtful fashion, but without much new material, except for some pertaining to Australian conditions.

Here and there the text makes mention of an author, sometimes with a date attached. The work would be of much greater value if adequate references to original publications had been given, to back up the statements made. Lecture audiences should not be bored with references, but in converting a series of scientific lectures into book form, references are almost essential

if the work is to be of more than passing interest. When such references are not given, the result is usually just another book, of little permanent value, to stand on the library shelves.

WALTER C. TOBIE

VETERINARY BACTERIOLOGY. *Third Edition.* *By Ival Arthur Merchant. The Iowa State College Press, Ames.* $7.00. viii + 683 pp.; ill. 1946.

After having examined a considerable number of confused, illogical, and at times even ungrammatical contributions on various phases of veterinary medicine, it is refreshing to encounter the present well-presented text on veterinary bacteriology.

Part 1 covers the general biology of microorganisms; part 2, infection, resistance, and immunity; part 3, classification and characteristics of pathogenic bacteria, yeasts, and molds; part 4, the filterable viruses and bacteriophage. Pathogenic protozoa are not included, since it is considered that these important organisms are better handled under the subject of parasitology. Each chapter is followed by a useful bibliography, the references usually being to textbooks or monographs, but with some references to journal articles. It is regrettable that no definite reference seems to be given to Nowak in *Documenta Microbiologica*, a source from which many of the excellent photomicrographs of microorganisms have been taken. Errors seem to be few. The "Fordas" mentioned as an investigator (p. 291) should be "Fordos."

As an introductory text in veterinary bacteriology, the present work is distinctly superior. In fact, it is better than many of the introductory texts on medical or on general bacteriology. The reviewer cannot help wishing that such a clear-cut text had been available when he first studied bacteriology.

WALTER C. TOBIE

DIAGNOSTIC BACTERIOLOGY. *A Textbook for the Isolation and Identification of Pathogenic Bacteria for Medical Bacteriology Laboratories. Third Edition.* *By Isabelle Gilbert Schaub and M. Kathleen Foley. The C. V. Mosby Company, St. Louis.* $4.50. 532 pp. 1947.

This is the third edition of a laboratory manual which has definitely proved its value. It is essentially a book of laboratory procedures and is designed primarily for the inexperienced hospital laboratory worker and the interne. The procedures have been chosen on the basis of the authors' experience and are clearly presented in more or less outline form. Information of a practical nature which is not readily available in the standard texts is given, as for example methods for separating bacteria when present in mixed culture. The value of culturing for anaerobic bacteria is stressed. These anaerobic organisms are often very significant clinically but are frequently overlooked or ignored because of inadequate mediums, methods, or awareness on the part of the laboratory worker.

With a few exceptions the content has been revised and brought up to date in the new edition. The most notable of the exceptions is the continued use of media made with infusion broth as a base. Peptones are now available which can replace, in most cases, the infusion. These peptones are constant in composition and promote much better growth of practically all bacteria. The fermented infusion broth used as a base for testing carbohydrate fermentation is very tedious to prepare and is not necessary.

The format of the book is the same as in the previous editions. The back of each page is left blank for notes. There is a good index.

E. PETRAN

APPLIED MEDICAL BACTERIOLOGY. *By Max S. Marshall, with the collaboration of Janet B. Gunnison, Alfred S. Lazarus, Elizabeth L. Morrison, and Marian C. Shevky. Lea and Febiger, Philadelphia.* $4.50. 340 pp.; ill. 1947.

This book presents in a very concise manner much of the pertinent material on the subject which one has had to dig out of the larger, more detailed textbooks previously. The first part of the book deals with fundamental laboratory procedures, such as microscopy, sterilization and disinfection, washing glassware, preparation of culture media, the general technic of cultivation, isolation, and counting of bacteria, and tests of antibiotics. There is a good chapter on the use of laboratory animals and the diseases to which they are susceptible. Methods of handling, inoculation, bleeding, and autopsy are described. The general technics used in serology, virology, and mycology are given briefly. There is a short discussion of sanitary bacteriology. Particularly valuable is a chapter on biologic products. The kinds of biologic products available and a list of producers are given; this is information not usually readily available. Another important chapter deals with "specimens." The principles and methods of collection, information needed by the laboratory worker, and postal regulations governing the shipment of infectious materials are concisely presented.

The last half of the book is devoted to Diseases. There is first a general statement about each disease included, its etiology, occurrence, course, and whether or not immunization procedures are available and what methods are used in treatment. Then a statement of

what specimens to secure and why certain specimens are not of value in the particular disease under consideration. This is followed by a section on laboratory procedures and finally one on reporting. The diseases covered include those caused by bacteria, viruses, and fungi. At the end of the book are two tables. The first gives in summary form the diseases, organisms, specimens needed, animals to be used, and serological tests. The second lists the diseases and the culture medium used for isolation and differentiation of the causative organism. Finally there is a section giving the formulae of the common stains and solutions used in staining. There is an adequate index.

The laboratory procedures given are the usual ones found in standard texts. In some instances newer methods are now available. This volume would be more valuable if published in loose leaf form so that individual sections could be revised and kept up to date. The almost complete absence of references is surprising and would be a handicap to those wishing to get more detailed information on certain procedures. On the whole the book can be recommended to the teacher, student, public health worker, and laboratory worker as a source of pertinent information on the field of medical bacteriology.

E. PETRAN

THE UNCONQUERED PLAGUE. *A Popular Story of Gonorrhea.*

By Harry Wain. International Universities Press, New York City. $1.50 (paper). viii + 119 pp.; ill. 1947.

This is a popular account of the activities of gonorrhea written with the view of telling the story of this disease in a straightforward manner, for the benefit of the interested layman. Ten chapters cover a description of the organism, its history, effects, means of transmission, and prophylaxis in a fashion that is neither medical nor moral, but which should make the book of great value to teachers and others who desire a readable account of this disease.

JOHN E. CUSHING

MOLECULES AGAINST MICROBES. *Sigma Introduction to Science Number 6.*

By E. S. Duthie. Sigma Books, London. 6s. 156 pp. + 8 plates + 5 charts; text ill. 1946.

An account, in popular style, of man's efforts to combat disease with chemical agents. The author assumes for the reader essentially no knowledge of chemistry or bacteriology and introduces the essentials of these sciences in conjunction with his story. He traces the development of chemotherapy from early to modern times and gives a detailed and interesting account of this field, particularly regarding the discovery and development of the sulfonamides and the antibiotics. The book is an excellent one and covers its field so well that the student as well as the layman can learn much from it.

JOHN E. CUSHING

CHEMOTHERAPIE BAKTERIELLER INFEKTIONEN. *Beiträge zur Arzneimitteltherapie. Band I. Third Edition.*

By Gerhard Domagk and Carl Hegler. S. Hirzel, Leipzig; J. W. Edwards, Ann Arbor. $10.00. xii + 446 pp. [1944] 1947.

This volume may be of use to students of the history of the development of sulfonamide therapy, but it appears to be of little value to the pharmacologist in 1948. The entire subject of sulfonamide chemotherapy has developed to such an overwhelming degree in the intervening years that the laboratory worker and teacher can scarcely afford to read a four-year-old text except for basic or historic material. The recent appearance of Northey's extensive monograph on this subject makes this all the more true.

The book is divided into two sections. Domagk has written the first part, which deals with the chemotherapy of bacterial infection from the viewpoint of the synthesis and pharmacology of the sulfonamide compounds. The text is replete with coined trade names for the various compounds, a fact that renders an intelligent grasp of the subject matter difficult. Recently-developed sulfonamides are not mentioned. There is, however, extensive consideration given to "Marfanil." The second part of the text has been written by Hegler and is concerned with the clinical aspects of treatment of bacterial infection with the sulfonamides.

The lithoprinting appears to be clear and sharp, but the reviewer found it difficult to read. The index is not complete and only very general terms are presented.

C. JELLEFF CARR

PULMONARY TUBERCULOSIS: *A Handbook for Students and Practitioners. Second Edition.*

By R. Y. Keers and B. G. Rigden, with a foreword by F. H. Young. A William Wood Book, The Williams & Wilkins Company, Baltimore. $5.00. xvi + 280 pp. + 122 plates. 1946.

In its clinical chapters, the new edition of this British handbook on pulmonary tuberculosis offers a concise and plainly authentic account of the diagnostic, therapeutic, and epidemiologic problems of the still largely unconquered disease. The authors may be

correct in stating that they can make no claim for any originality of method or material, but they are experienced clinicians and fully conversant with the medical and public health aspects of the disease. The illustrative material is well selected and technically far above the standards of a compendium.

The discussion of the constitutional features of tuberculosis is less satisfactory and often inconsistent. The significance of genetically determined variations in susceptibility and resistance to tuberculous infection is minimized and rather sketchily documented.

FRANZ J. KALLMANN

THE PAPWORTH FAMILIES: *A 25 Years Survey.*

By E. M. Brieger, with a preface by Sir Arthur Salusbury MacNalty. Grune & Stratton, New York. $12.00. 674 pp. + 1 table; ill. 1946.

This sizable volume is the documentary success story of a humanitarian and mission-like experiment aiming at the coordinated conquest of the medical, social, and epidemiologic problems of tuberculosis. It covers the first 25 years of the thriving development of Papworth Village Settlement, that exemplary British community for employable tuberculous patients which grew from the smallest beginnings to a prosperous colony of 142 cottages and hostels housing the families of cured staff members and married ex-patients with a total of 368 children (about one-third of them born in the village). The book is a noble document in the history of tuberculosis prevention and, regardless of certain basic shortcomings, a glowing tribute to the pioneer work of the author's predecessor and philanthropic founder of the settlement, the late Sir Pendrill Varrier-Jones.

One of the main objectives of the colony has been to raise a "tuberculosis free herd" by providing adequate housing and food supplies, freedom from anxiety by means of assured employment and liberal education, and the potential benefits of an active social life without bias and strenuous competition. The author's faith in the creditable goals of the settlement is expressed in the proud statement that "the children born in Papworth village have not shown any symptoms of either active extra-pulmonary or pulmonary tuberculosis, and no death from tuberculosis has been recorded." The obvious merits of the experiment may be seen in the demonstration of the controllability of the spread of tuberculous infection under most favorable and intelligently supervised environmental conditions.

The weakness of the author's euthenic optimism reveals itself in the utterly uncritical tendency to promote the undisputed usefulness of one curative or "herd-raising" principle by depreciating that of any other. His claim that "there is no need for the supposition of a hereditary predisposition" is based on wishful generalizations rather than scientific facts. The author does not seem to realize that tuberculosis control in a modern world cannot be accomplished entirely through mass segregation of affected families under rural glasshouse conditions.

FRANZ J. KALLMANN

ENDOCRINOLOGY OF NEOPLASTIC DISEASES. *A Symposium by Eighteen Authors. Oxford Medical Publications. Edited by Gray H. Twombly and George T. Pack. Oxford University Press, New York.* $11.00. vi + 392 pp.; ill. 1947.

This is a collection of excellent review articles covering the entire field of the relationship of the endocrines to cancer. The endocrine effects of hormone-producing tumors are treated with the same thoroughness as the relationship of hormones to cancers of the breast and the prostate. I. T. Nathanson presents the relationship of the steroid hormones to cancer of the breast in a masterly fashion. J. H. Farrow gives an excellent account of the effect of sex hormones on skeletal metastases from breast cancer. This article is based on the author's clinical experience at the Memorial Hospital for Cancer in New York City. It is of great interest that estrogens and androgens have a similar effect on skeletal metastases from mammary cancer. However, retardation of malignant growth brought about by administration of these steroid hormones is inconstant and of a temporary nature. This is also true for the treatment of carcinoma of the prostate by castration and administration of estrogens. Moore, Dean, Woodard and Twombly have written two superb chapters on this subject.

The study of adrenal cortical tumors has led to a number of significant physiological observations and theories. A. T. Kenyon has written a review, both lucid and comprehensive, of this field.

Considering the wealth of information in every chapter of this fascinating symposium, it cannot be too strongly recommended.

WALTER FLEISCHMANN

THE PATHOLOGY OF NUTRITIONAL DISEASE. *Physiological and Morphological Changes Which Result from Deficiencies of the Essential Elements, Amino Acids, Vitamins, and Fatty Acids.*

By Richard H. Follis, Jr. Charles C. Thomas, Springfield, Illinois; Blackwell Scientific Publications, Oxford; The Ryerson Press, Toronto. $6.75. xii + 291 pp.; ill. 1948.

This book describes the physiological and morphological changes which result from deficiencies of the fourteen essential inorganic elements, the ten essential amino acids, the fifteen best known vitamins, and the essential

fatty acids. The concluding section, entitled "The pathologic anatomy of specific tissues—a recapitulation and comparison," deals with epithelial tissues, mesenchymal tissues, blood-forming tissues, vessels and the coagulation mechanism, muscle tissues, and nervous tissues. The author has devoted much time to the study of several of the deficiency states and is a well known investigator in this field.

The science of nutrition was developed principally by biochemists. Many important discoveries of hitherto unsuspected nutrients were made before pathologists made very significant contributions to our knowledge of what happens when body chemistry is perverted by inadequate supply, or total deprivation, of single indispensable nutrient chemical substances. Biochemists who made fundamental discoveries about foods and nutrition were generally unable to comprehend the meaning of symptoms of nutritive failure from specific causes. For this reason the writings relating to malnutrition contain much that is faulty in observation and intrepretation. After the pioneering studies of Wolbach and his associates, several pathologists have devoted their efforts to the study of deficiency states with great success. Critical readers will see throughout the book evidence that the author has made a careful study of almost all of the scientific papers which contribute to an understanding of his subject. Evidence of keen insight and clear interpretation are to be found on every page. The book will be appreciated by everyone interested in biology, biochemistry, physiology, and medicine as well as to pathologists.

E. V. McCollum

ALLERGY. *Second Edition.*

By Erich Urbach and Philip M. Gottlieb. Grune & Stratton, New York. $15.00. xx + 968 pp.; ill. 1946.

The second edition of *Allergy* by Urbach and Gottlieb differs from the first edition in that thirteen hundred references have been added. The publisher's advertisement states that this addition indicates "the vast amount of recent clinical and laboratory findings correlated and evaluated in this standard work on allergy." The book is encyclopedic in type. Abstracts of all of the references which have been mentioned as the reason for a second edition have been incorporated in the body of the text. Good and poor investigations are referred to, but little attempt has been made to separate the chaff from the grain. The reviewer has not attempted to read this volume in detail. As a reference book it can be recommended because the entire field of hypersensitivity and allergy has been summarized. Methods of treatment are recorded and numerous references are cited to support the many therapeutic measures. If the inexperienced physician reads the book, I am sure he will be confused. The discriminating reader might find it of assistance if a library is not available.

Leslie N. Gay

L'HYPERINSULINIE. *Les États de Suractivité Fonctionnelle du Pancréas Endocrine en Médecine Expérimentale et en Clinique.*

By Marcel Sendrail. Masson et Cie., Paris. 500 fr. (paper). iv + 256 pp. + 2 plates; text ill. 1947.

In reviewing the literature, largely American, on hyperinsulinism attributable to a tumor of the islets of Langerhans it appeared to the author that the problem "exceeded the bounds set by simple langerhansian tumors." "It is a biological problem, with multiple experimental, cytological, symptomatic, and therapeutic ramifications, whose liaison with problems connected with endocrinology demands ample exposition, and merits a synthetic study which has not yet been accorded it." This has now been adequately achieved by the author; and several sections, well documented from European and American sources, treat every phase of hypoglycaemia and hyperinsulinism. Probably of greatest interest to readers of the Quarterly is the chapter on experimental hyperinsulinism. The author, incidentally, introduced the insulin tolerance test into routine clinical medicine in 1928. There is an "analytical table of contents" in the French manner, and chapter bibliographies, but no general index.

H. R. Catchpole

METHODS FOR LABORATORY TECHNICIANS. *War Department Technical Manual TM 8-227.*

U. S. Government Printing Office, Washington, D. C. Paper. v + 618 pp.; ill. 1946.

This manual might have been better called "Laboratory Methods for *Army Medical* Laboratory Technicians." It is a revision of the previous issue which was hurriedly compiled and published under "emergency" conditions in 1941. It has been expanded from 447 pp. to 618 pp., and presents a large amount of condensed and useful information on working methods in bacteriology, parasitology, hematology, clinical biochemistry, and related topics. It should be of value in civilian as well as in military medical laboratories.

Although the manual should be very useful to army medical laboratory *officers*, some of the material will probably be exceedingly heavy going for the average army medical *technician*. A number of the methods have been greatly over-elaborated by specialists who have shown but little regard for average army working

conditions. Thus, a very complicated and precise method for determining cholesterol in blood is given, covering 9 pages of text and employing 11 different reagents. The blood cholesterol method of 1941, which occupied only 1 page of text and used only 4 reagents, was probably far more practical for ordinary clinical use.

It is doubtful whether some of the more complicated procedures will ever be *widely* used in army clinical laboratories. In most cases they are likely to remain only a theoretical "on paper" dream. Simpler methods, adapted from other sources, will be much more commonly used, or else the determinations will not be done at all.

Under these conditions, it is difficult to decide whether it is fortunate or unfortunate that this revision was delayed so long. Back in 1942 and 1943, the reviewer had some contact with this manual. At that time the work of revision was a sort of football, kicked about from one office of the Army Medical Department to another. No one seemed to have the authority to make the final decision as to what should or should not be included. This may account for the fact that this revision was not published in time to be used in World War II.

WALTER C. TOBIE

THE TREATMENT OF DRUG ADDICTS. *Bulletin of the Health Organization, Volume XII, Number 4.*

By P. O. Wolff. League of Nations, Geneva; Columbia University Press, International Documents Service, New York. $1.25 (paper). 229 pp. 1945–46.

This excellent survey, based on more than twenty years of personal international experience in the field, deals primarily with treatment of addiction to morphine and the great number of other opiates. Cocaine and marihuana, which apparently produce less profound metabolic changes, and therefore fewer physiological problems in treatment, are discussed less extensively. The author reports on all forms of withdrawal treatment, although his own inclination is unmistakably toward sudden withdrawal in closed institutions. Auxiliary treatments by narcotic drugs, proteins, endocrine preparations, lipids, diuretics, etc. are described in detail. Psychotherapy and after-treatment are given due attention. The author favors usually methods of treatment as developed in this country by Himmelsbach, Kolb, etc. Yet in reporting additional experiences and opinions of French, English, German, South American, Indian, Chinese, etc. workers he provides a most valuable source of otherwise little accessible information and stimulation to North Americans interested in the field. A fine bibliography of 477 numbers allows the following up of special problems like congenital addiction (babies of addict-mothers). This volume is a most valuable tool in tackling one of the most disturbing problems in contemporary therapeutics.

ERWIN H. ACKERKNECHT

PSYCHOLOGY AND ANIMAL BEHAVIOR

THE PSYCHOLOGY OF HUMAN DIFFERENCES. *The Century Psychology Series.*

By Leona E. Tyler. D. Appleton-Century Company, New York and London. $3.75. xiv + 420 pp.; ill. 1947.

Much of the content of psychology is concerned with the description and analysis of average human behavior. This is as it should be, since one of the main functions of the science of psychology is to provide useful generalizations about the way people as a whole learn, think, and act. There is, however, another large group of generalizations in psychology which describe the ways in which people differ from the average. This body of knowledge is usually taught in courses labelled Individual Differences, Differential Psychology, or Human Variability. Tyler's book is suitable as a text for undergraduate courses of this nature.

The book is divided into four major sections. Part I is introductory, being largely concerned with a survey of the ways in which human characteristics vary. Part II deals with the major group differences: sex, race, nationality, class, and age differences. There are also in this section two special chapters, one on the feebleminded and the other on the genius. Part III discusses factors related to individual differences: the relationship of mental to physical characteristics, the effects of practice, and the contributions of hereditary and environmental factors to individual differences. Part IV is concerned with the appraisal of the individual. It contains two chapters on the measurement of aptitudes and the search for basic traits.

The field of individual differences means different things to different people. The contents of this book, however, will probably satisfy most psychologists. Especially noteworthy, in the reviewer's opinion, is the inclusion of a chapter on age differences and another on the effects of practice and training on individual differences. Differences in age contribute more to the total variability of certain kinds of human abilities than do race, sex, or class differences. Yet age as a factor contributing to individual differences is very often ignored. The effects of practice on individual differences have also been largely neglected, although the results of research in this area have broad implications for psychology and education.

Tyler's style of writing deserves special mention because it is so clear. As an illustration, she has been able to write about unusually complex statistical techniques, e.g., factor analysis, in a way that should leave

the undergraduate student with some appreciation of what these techniques do. This in itself is a commendable achievement. Although she has by no means summarized all the literature in the field of individual differences, her interpretation of research findings is sound and thought-provoking. All in all, this should be a stimulating book for students in psychology, education, the social sciences, and related fields.

A. CHAPANIS

LA PSICOLOGIA SPERIMENTALE DI SANTE DE SANCTIS. *By Romolo Appicciafuoco, with preface by Ferruccio Banissoni. Casa Editrice Orsa Maggiore, Roma.* L.250 (paper). 292 pp. 1946.

PSYCHOLOGICAL ATLAS.

By David Katz. Philosophical Library, New York. $5.00. x + 142 pp.; ill. 1948.

This is a collection of charts, diagrams, and pictures published with the intention of "arousing a zeal for the study of psychology." The materials are those which Katz has used to illustrate his lectures. They are certain to impress the reader with the author's versatility, but whether they will serve to create any interest in psychology in this country is not so certain. The descriptions accompanying the illustrations are extremely brief. Only 36 of the figures are from sources written in English. Something of the range of interests covered will be apparent from considering the first and last pictures of some of the major divisions of the book. Under General Psychology appear 105 figures, the first of which is a view of the human brain, and the last the Chinese ideograms for psychology. Under Character and Topology are 56 illustrations, the first showing the muscles of the face, and the last the Szondi test. Developmental Psychology (74 illustrations) starts with the change in relative proportions of the human body from infancy to 25 years, and ends with a drawing of a child's imagined spatial relations of the days of the week. The 24 figures under Physical Handicaps start with deaf-mutes around a piano learning to recognize rhythms and end with foot-writing by an armless boy. The first figure of the 36 under Medical Psychology shows an apparatus for teaching percussion to medical students, and the last shows figurines made by natives of the French Congo and by a schizophrenic patient. Eleven pictures appear under Occult Phenomena, starting with a divining rod and ending with "a diagram representing an occult philosophy of the significance of bodily proportions." The sections on Applied and Animal Psychology, with 21 and 26 illustrations respectively, reveal the same catholicity of interests. The final 41 figures are photographs of Eminent Psychologists. As P. L. Harriman states in the Foreword, this atlas will "furnish material for many a pleasant and stimulating hour." The title page states that there are 400 illustrations, the dust cover says 396, and the reviewer was able to find 394.

R. B. BROMILEY

HANDBOOK OF GENERAL PSYCHOLOGY. *A Summary of Essentials and a Dictionary of Terms.*

By W. B. Pillsbury and L. A. Pennington. The Dryden Press, New York. $1.75. xiv + 400 pp.; ill. [1942]; 1946.

According to the authors, "the purpose of this volume is twofold. *First*, the subject matter of general psychology has been summarized for the convenience of the general reader who wishes to understand the behavior of the normal adult individual.... *Second*, the book has been arranged to serve as a guide for the college student who studies psychology for the first time."

Upon inspection, this book turns out to be a condensed elementary psychology—midway between a textbook and an outline such as one might find in the *Student Outline Series*. Although there are 400 pages in the book, the pages are small, and only 294 of them are devoted to the Summary of Essentials. (Actually, another 45 pages must be subtracted for the test questions and references which follow each chapter.) There is nothing inherently wrong with brevity, of course, and a condensed handbook of elementary psychology could be very useful if it were well written. This one is not. It is full of declarative statements which, on the whole, are terribly dull. In addition, the authors have studded the text with asterisks to indicate words which are defined in the Dictionary of Terms (Part II of the book). Perhaps these actually do assist the reader. The reviewer, however, found them extremely distracting.

The dictionary of terms mentioned above occupies 70 pages. It contains a few definitions which are clearly incorrect (e.g., "Deuteranopia: A type of partial colorblindness in which the green is perceived as darker than the red"), a few which are partially correct, and a fair number which are so vague as to be of questionable value (e.g., "Dark adaptation: The increased sensitivity of the eye to light"; "Co-twin control: Same as training method").

This is probably the kind of book which would be of use to a poor student who needed to memorize a series of facts and definitions in their barest essentials so that he could pass a final examination. The discriminating reader who wants to know about psychology is advised to look elsewhere.

A. CHAPANIS

FURTHER EFFECTS OF ADDED THIAMIN ON LEARNING AND OTHER PROCESSES. *Teachers College, Columbia University, Contributions to Education, No. 928.* *By Ruth Flinn Harrell. Bureau of Publications, Teachers College, Columbia University, New York.* $2.75. viii + 102 pp. + 4 plates; text ill. 1947.

This monograph is a report of original research, extending the author's earlier work on the effects of thiamin supplementation on learning and intelligence. One hundred and twenty children, four to eighteen years of age, were studied at the Presbyterian Orphan's Home at Lynchburg, Virginia, over a two-year period. At the start of the experiment, the children were paired on the basis of age, sex, size, education, and family of origin. In the first year, one member of each pair was fed two mg. of thiamin in tablet form each night at bedtime. The control member of each pair received a placebo indistinguishable from the thiamin tablet. Careful controls were accomplished with a coding system such that neither the children, the adults administering the tablets, nor the test administrators knew which children were receiving the supplementary thiamin. At the end of one year, the experiment was suspended for 60 days during which time no tablets were administered. Then each group was divided in two. One half was continued on the same treatment for a second year; the other half of each group received the reverse treatment, i.e., they were shifted from thiamin to placebo and vice versa.

A battery of tests was administered by experienced personnel at intervals throughout the experimental period. The CAVD and Kuhlmann-Anderson Tests of intelligence, the Snellen and Telebinocular Tests of visual acuity, a choice-reaction timing test, and the Metropolitan Achievement Test (educational achievement) were given at the start of the program in September 1942, nine months later in June 1943, and seven months after the resumption of tablet administration in the second year, in June 1944. In addition, measures of memorization and retention, code substitution, height and weight, and the incidence of colds were taken at more frequent intervals.

The over-all design of this experiment was excellent, but the author's conclusion, at the end of the work, that the thiamin-fed children showed greater gains in every test of ability must be critically evaluated. Although it is true that the children of the thiamin group made greater average gains in each measure, it is by no means clear that these gains are attributable to thiamin supplementation alone. In the first place, in almost every test used, the thiamin-fed children were inferior to the controls in the initial testing. Since the tests used are not of the highest reliability, it might well be expected, in terms of statistical regression alone, that the thiamin-fed children would show greater gains. In the second place, as the author's statistical analysis of the results indicates, not all the greater gains of the thiamin group are statistically significant. That is to say, some of the differences may be attributable to chance alone (viz., the difference in gains in the Kuhlmann-Anderson Test of intelligence, one of the visual acuity measures, the educational achievement test, and weight). In fact, only seven of the 15 measures taken showed greater gains of the thiamin group that were significant at the one per cent level of confidence or better, viz., four of the visual acuity measures, the code substitution test, one retention test, and the memorization test. In the other measures, the differences were between the one and five per cent levels of confidence.

An extreme example of the dangers inherent in drawing conclusions from this statistical treatment of the data may illustrate the need for caution in interpreting these results. In the measures of visual acuity made with the Telebinocular Test, it was found that the greater gain in the left eyes of the thiamin-fed children was such that it could be expected by chance alone only twice in a million times, while the difference in the gains in the right eye could have occurred by chance alone as often as one time in ten. Statistically, this is the most significant result of the whole experiment; practically, it is not. It makes no physiological sense and seems to be only a reflection of the unreliability of the test used.

Further caution is needed in generalizing from the results obtained with this selected group of children. In the first place, as the author points out, the orphanage diet was not well-balanced. Although it contained more than adequate quantities of milk, it was low on eggs and meat. Furthermore, the vegetables were routinely overcooked, and efforts were made to prevent the use of enriched flour in the preparation of food. Secondly, the average intelligence quotient of the children used in the study was about 91 (Kuhlmann-Anderson), which means that the group was on the low side of average intelligence.

This study represents an important experimental beginning in the investigation of the problem of nutritional and biochemical factors in learning, intelligence, and other complex behavioral capacities. It cannot be urged too strongly, however, that its results and conclusions are to be viewed with great reserve, until it is sufficiently clear which of them can be verified and which are experimental artifacts.

ELIOT STELLAR

DEVELOPING YOUR CHILD'S PERSONALITY. *By Gelolo McHugh. D. Appleton-Century Company, New York and London.* $2.75. xii + 234 pp. 1947.

This is a pleasant but unimportant book along usual lines. Preparations for parenthood, fundamentals of child care, eating habits, toilet training, thumb-sucking,

sex education, speech development, social development, and the dilemma of the next child are dealt with conscientiously. There is no quarrel with McHugh's thinking on these subjects. Indeed, it would be a harmless book (and as such possibly even reassuring) to give to a young wife or mother. The main criticism to be made is that in the author's effort to be casual and matter of fact about the whole thing, he has employed a glib, unemphatic style which leaves the reader rested but wondering if anything was actually said.

HELEN HEWITT ARTHUR

NON-PROJECTIVE PERSONALITY TESTS. *Annals of The New York Academy of Sciences, Volume XLVI, Article 7.*

By Harold A. Abramson, Keeve Brodman, Harold J. Harris, George G. Killinger, Bela Mittelmann, Zygmunt A. Piotrowski, David Rapaport, Roy Schafer, Martin Scheerer, David Wechsler, Arthur Weider, Harold G. Wolff, Edith Wladkowsky, and Joseph Zubin. The New York Academy of Sciences, New York. $1.75 (paper). Pp. 531–678. 1946.

THE IMPACT OF A CHILDREN'S STORY ON MOTHERS AND CHILDREN. *Monographs of the Society for Research in Child Development, Volume XI, Serial Number 42, Number 1, 1946.*

By Martha Wolfenstein. Society for Research in Child Development, National Research Council, Washington, D. C. $1.50 (paper). iv + 54 pp. 1947.

This is a well-written report on a very interesting and original (if not very elaborate) piece of research in the field of child development. A panel of child psychologists outlined the ingredients for a child's story centered around the provocative elements in a youngster's reaction to the anticipation and actual arrival of a sibling. A professional writer assembled an ingenious tale entitled "Sally and the Baby and the Rampatan" to fit the specifications. Then this story was submitted to a group of ten educated mothers to read to their respective four year olds. The children's subsequent reactions to the story were noted in their play activities and in the group on a rereading of the story by the teacher. The mothers' reactions to the story were solicited and correlated with the individual child's response. Upon evaluating the material thus acquired, it became clear that each mother colored the story with her own unconscious reactions to the provocative situation depicted and transmitted attitudes to her listening child which markedly affected his response to the tale. Case histories included in this monograph are particularly interesting. While this study was carried out on a statistically insignificant group, the dynamic viewpoint of the report makes the findings well worth examining. More studies of this calibre and using the medium of the child's story should be forthcoming.

HELEN HEWITT ARTHUR

LEARNING TO USE HEARING AIDS: *A Study of Factors Influencing the Decision of Children to Wear Hearing Aids. Report of the Subcommittee of the Committee on Problems of Deafness of the National Research Council.*

By Arthur I. Gates and Rose E. Kushner. Bureau of Publications, Teachers College, Columbia University, New York. Free upon request (paper). iv + 77 pp. 1946.

This is a report of a study made on 38 children who needed and were given hearing aids. It was found that the children who adapted themselves to using the hearing aid were the better adjusted, more intelligent children to begin with. Insecure, less adequate youngsters discarded the hearing aid for reasons of embarrassment or inability to handle the aid successfully. The authors suggest a number of ways in which all children needing such aids might be persuaded to accept them more readily and with less emotional resistance.

HELEN HEWITT ARTHUR

MAN FOR HIMSELF. *An Inquiry into the Psychology of Ethics.*

By Erich Fromm. Rinehart and Company, New York, Toronto. $3.00. xiv + 254 pp. 1947.

In this very scholarly volume, Erich Fromm presents a philosophical study of moral and ethical standards based on "rational value judgments." These rational value judgments of human nature and human needs are made possible by the insight of modern psychology —to which we are so indebted to Freud. But the development of associated ethical goals is an original and highly important contribution to the science of psychiatry, which has always been accused of breaking with accepted moral standards without providing alternative values. Psychiatrists and a great many others who work with people or who are philosophers groping for a solution to our modern moral muddle will be indebted to Fromm for his convincing and encouraging thesis that there are constructive, emotionally healthy, ethical standards which every mature individual must accept and live by.

The author begins his book, appropriately, by developing the case for humanistic ethics—a standard of constructive values based on the knowledge of man and not on some preconceived idea of what man should be. The basic principle of this philosophy is that "virtue is the same as man's pursuit of obligations toward himself and vice the same as self-mutilation." Following this discussion, Fromm extends his carefully worded build-up to give an incisive, dynamic description of character,

He divides his concept of "dynamic character" into two orientations—the non-productive and the productive. Within the non-productive frame are the neurotic, mentally unhealthy character types. Next, in logical sequence, Fromm attacks directly the problem of resolving the conventional (or authoritarian) ideas of morality with the morality of the humanistic philosophy. Questions of selfishness, conscience, pleasure, faith, good and evil are taken up with the same deeply philosophical yet pragmatic approach which makes the reader feel as if he were finding answers for himself.

Man for Himself is not an easy book to read. It is too fundamental to be facile. However, it is an enriching experience emotionally and intellectually, to have followed the author's beautifully clear, scholarly thinking from premise to conclusion.

HELEN HEWITT ARTHUR

MENTAL HYGIENE. *Sixth Edition.*

By J. Lowrey Fendrich, Jr. Willing Publishing Company, Los Angeles. $1.00 (paper). 76 pp. 1947.

THE PSYCHOLOGY OF CHILDHOOD.

By Evelyn Whitell. Willing Publishing Company, Los Angeles. $1.00 (paper). 73 pp. 1947.

These are two highly moral little tracts written by non-professional people for an unspecified but certainly a very naive audience. The booklet on *Mental Hygiene* reads like a vigorous sermon in which the reader is exhorted, among other things, to "live one day at a time," "to think positively," and in general to seek peace and power from God.

The pamphlet with the resounding and misleading title of *The Psychology of Childhood* is a series of completely unscientific, sentimental little notes on children, from prenatal days onward. For example, the expectant mother is adjured to repeat "Mother's Song" hourly for its salutary effect on her foetus. Much space is devoted to the need for prayer and uplift involving family and children alike.

Although unrealistic, unoriginal, and uninteresting, neither pamphlet contains any vicious untruth. Most deceiving are the ambitious titles, which represent a transparent attempt to capitalize on the modern interest in mental health as a wedge for moralistic religious propagandizing.

HELEN HEWITT ARTHUR

PSYCHIATRY FOR EVERYMAN.

By J. A. C. Brown. Philosophical Library, New York. $3.00. viii + 247 pp. 1947.

This book succeeds in giving a first-rate account of the development of psychiatry in simple terms which are easily understandable. Brown has discussed various ideologies within the psychiatric field and its outstanding symptom states. He succeeds in demonstrating that "mind is not a thing but a process; not a noun but a verb." The book can be recommended for general use.

WENDELL MUNCIE

PSYCHOPATHOLOGY. *A Survey of Modern Approaches. Fourth Edition.*

By J. Ernest Nicole. A William Wood Book, The Williams & Wilkins Company, Baltimore. $4.75. viii + 268 pp. 1946.

The fourth edition of Nicole's well-known work brings the survey of the field up to date with an extensive bibliography. This is an excellent guide to modern trends in psychopathology. It includes a good historical background and extensive statements of each of the principal contributions to modern eclecticism: Freud's psychoanalysis; Adler's individual psychology; Jung's analytical psychology; the theories of T. S. Rivers; Watson's behaviorism; Kempf's contributions; the endocrine, biochemical, and other physiological and anatomical considerations; Kretschmer's constitutional studies; ethnological and sociological evidence; modern schools of psychology—Gestalt, Hormic, and so on. This most useful text will repay study by any one interested in the many trends in present day psychopathology.

WENDELL MUNCIE

INTRODUCTION TO MEDICAL PSYCHOLOGY.

By L. Erwin Wexberg. Grune & Stratton, New York. $3.50. x + 171 pp. 1947.

This little book is the outgrowth of lectures which the author gave during the seven years he taught undergraduates at Louisiana State University School of Medicine. The chapter headings will indicate the scope of the book: Individual and Community, Knowledge and Action, Emotions and Instincts, Temperament, Personality, and Character, Genetic Psychology, Methods and Technics of Clinical Psychology. This material is well presented, the book is quite readable, and could well be used in introductory courses in medical psychology.

WENDELL MUNCIE

HYPNOTHERAPY. *A Survey of the Literature. The Menninger Foundation Monograph Series Number 5.*

By Margaret Brenman and Merton M. Gill. International Universities Press, New York. $4.50. xii + 276 pp. 1947.

This volume is composed of three distinct and somewhat divergent parts. The first and most important section of the book is a comprehensive, intelligently organized integration of modern thought on the different aspects of hypnotherapy. After a brief chapter on the historical development of hypnotherapy, the authors devote a chapter to Methods of Inducing and Terminating Hypnosis. Procedures for "sleeping methods," drug hypnosis, "Hypnoidization" (a sort of pre-hypnotic relaxation), and "waking methods" are described carefully, often in direct quotations from the original investigators. It is a most helpful presentation and clarifies immediately much of the hocus-pocus that surrounds the hypnotizing process in the minds of those who have not tried to do it. The next chapter, entitled Susceptibility to Hypnosis, considers what factors are required for a good hypnotic reaction and what suggestions have been made to improve a subject's response. The fourth chapter is perhaps the most fascinating to a clinician, in that here the therapeutic applications of hypnosis are presented. Both authors are fully experienced in the use of the hypnotic technique and, although their purpose here is to make a survey of what has been done along these lines, they deal with the subject in an authoritative way, contributing creative details of their own experience to lend credence and life to the whole discussion. Chapter five is on The Theory of Hypnosis. Here a variety of points of view is presented, but no definite conclusions have been reached. The survey is summarized in chapter six, and future problems needing investigation are pointed up. All in all, this section of the book is excellent and will be a stimulating and practical reference text for professional people interested either in psychiatric research or therapy.

Section II is comprised of four case histories of patients treated by hypnotherapy. They make fascinating reading and certainly present evidence in favor of the therapeutic method under consideration. However, the cases, chosen exclusively from the authors' own professional circle, tend to dispel the generous effect of section I. Here the "survey" has narrowed down to reporting very special and highly personalized work rather than reporting on a more general sampling of therapeutic work in the field. The tacit implication seems to be that the home of modern dynamic hypnotherapy is in Topeka. Maybe it is.

The third part of the volume is a tedious tour de force by Margaret Brenman to illustrate the use of hypnotic techniques in a research project. The study was originally submitted as her doctorate thesis and, even though considerably condensed here, is still dull reading. It should be granted that she makes a point, but it seems to contribute very little to the stature of the book as a whole.

HELEN HEWITT ARTHUR

CONCEPTIONS OF MODERN PSYCHIATRY. *The First William Alanson White Memorial Lectures. Psychiatry: Journal of the Biology and Pathology of Interpersonal Relations, Volume Three, Number One, February 1940 and Volume Eight, Number Two, May 1945.*

By Harry Stack Sullivan, with a Critical Appraisal of the Theory, by Patrick Mullahy. The William Alanson White Psychiatric Foundation, Washington, D. C. $2.00. viii + 147 pp. 1945.

This is the second printing of Sullivan's first William Alanson White Memorial Lectures, and constitutes an excellent statement of the author's views concerning personality structure and its study as the study of the "relatively enduring pattern of recurrent interpersonal situations which characterize a human life." It furnishes an important statement of the Washington Psychoanalytic Institute's basic principles. There are some critical notes appended by Patrick Mullahy.

WENDELL MUNCIE

FREUD: ON WAR, SEX AND NEUROSIS.

Edited by Sander Katz; translated by Joan Riviere, Alix and James Strachey, R. C. McWatters, E. B. Herford and E. Colburn Mayne, with glossary and preface by Paul Goodman. Arts and Sciences Press, New York. $3.00. 288 pp. 1947.

This varied collection of out-of-print papers by Freud ranges chronologically from the classic study of "Dora: an Analysis of a Case of Hysteria" (1905) to "The Taboo of Virginity" (1918), thus covering the "heroic" period of psychoanalysis. In this middle period of his career, beginning with the use of dreams for therapeutic ends in the case of Dora, Freud had already established his novel concepts of "neurasthenia" and the importance of sex and was engaged in the application of his psychoanalytic technique and theory. Not only the new cases in his clinical practice, but anthropological data and common social experience entered the ambit of his thought.

In addition to the essays already named, the selection includes the following: One of the Difficulties of Psychoanalysis (1917); Obsessive Acts and Religious Practices (1907); The Sexual Enlightenment of Children (1907); "Civilized" Sexual Morality and Modern Nervousness (1908); Contributions to the Psychology of Love: A Special Type of Choice of Object Made by Men (1910), and The Most Prevalent Form of Degradation in Erotic Life (1912); Thoughts for the Times on War and Death (1917). For all readers of Freud, this volume is a welcome addition to the available literature.

BENTLEY GLASS

THE WORLD WITHIN. *Fiction Illuminating Neuroses of Our Time.*

Edited by Mary Louise Aswell, with an introduction and analyses by Frederic Wertham. Whittlesey House, McGraw-Hill Book Company, New York and London. $3.75. xxviii + 376 pp. 1947.

This volume contains material from past and current literature dealing with psychopathologic states (not all strictly neurotic), with introductory statements by Mary L. Aswell, and analyses by Wertham. Dostoievsky, Chekov, Proust, Kafka, E. B. White, Faulkner, Robert M. Coates, and others are represented. The relationship between belles-lettrist intention and unconscious psychopathologic processes is shown.

WENDELL MUNCIE

THE MIND IN ACTION.

By Eric Berne. Simon and Schuster, New York. $3.00. xxii + 320 pp. 1947.

This is an excellent statement which begins with objective facts about man and ends with dynamic psychology of the Freudian variety. It can be recommended highly for the audience to which it is directed.

WENDELL MUNCIE

PRACTICAL PSYCHIATRY. *Between Mental Health and Mental Disease.*

By B. Liber. Melior Books, New York. $3.50. xiv + 412 pp. 1947.

This book, hailed as epoch-making by its publishers, falls far short of the mark. It is so full of biased or arguable statements made in a dogmatic fashion that a critical reader tends to suspect the entirety. This is unfortunate, for there are some kernels of wisdom in it. Let the reader make his own choice!

WENDELL MUNCIE

PRACTICAL CLINICAL PSYCHIATRY. *Sixth Edition.*

By Edward A. Strecker, Franklin G. Ebaugh, Jack R. Ewalt, and the section on Psychopathologic Problems of Childhood by Leo Kanner. The Blakiston Company, Philadelphia and Toronto. $5.00. xii + 476 pp. + 1 chart; ill. 1947.

This sixth edition of Strecker and Ebaugh's popular textbook includes Jack Ewalt as associate author. The material of this textbook is now so well known as not to require any special statement. It has gone through more editions than any other textbook in psychiatry, and is widely used. The book follows the psychobiological principles of Adolph Meyer, is replete with condensed case histories, and the suggestions for treatment are well given.

WENDELL MUNCIE

SYNOPSIS OF NEUROPSYCHIATRY. *Second Edition.*

By Lowell S. Selling. The C. V. Mosby Company, St. Louis. $6.50. 561 pp. + 1 plate; ill. 1947.

If there is any reason for a synopsis at all, this is good enough. There are a great many things throughout the text of value and some things about which one might be quite critical. Of the latter, one may point out, as difficult to understand or accept, what Selling calls "parapsychoses." I am unable to identify these patients from the brief descriptions he gives. His recommendation for extensive electro-shock therapy followed by psychotherapy is quite a shock to this reviewer. On the whole, there seems to be less to criticize in those chapters which have to do with neurology rather than psychiatry. The book could be of some use for a quick review of material for the Board Examinations.

WENDELL MUNCIE

INTRODUCTION TO PSYCHOBIOLOGY AND PSYCHIATRY. *Second Edition.*

By Esther Loring Richards. The C. V. Mosby Company, St. Louis. $3.75. 419 pp. 1946.

This second edition of Esther Richards' popular book for nurses contains a considerable appendix on therapeutic methods and on special psychological and physiological tests useful in psychiatry. The book is well known, the case histories are succinctly presented, and the presentation material has that special quality of rugged common sense which Esther Richards' large audience of medical students, nurses, and laymen have always appreciated. It is noted in passing that Monez is a Portuguese, not a Frenchman.

WENDELL MUNCIE

RITUAL: PSYCHO-ANALYTIC STUDIES. *The Psychological Problems of Religion.*

By Theodor Reik, with a preface by Sigm. Freud. Translated from the second German edition by Douglas Bryan. Farrar, Straus and Company, New York. $5.00. iv + 367 pp. 1946.

Reik's psychoanalytic investigations of certain religious rituals have long been regarded as a classic contribution to psychoanalytic literature. Originally conceived by the author in 1914–15, under Freud's guidance, these four papers were first published in an English translation in 1931. This current American edition, translated from the second German edition by Douglas Bryan, is designed no doubt to fill the increasing demand in this country for more Freudian literature and possibly also to reawaken interest in the scholarly, earnest, sometimes pedantic psychoanalytic research of which this volume is surely the prototype.

The topics selected for investigation are all interest-

ing. The first is Couvade and the Psychogenesis of the Fear of Retaliation; the second, The Puberty Rites of Savages; third, Kol Nidre; and fourth, The Shofar. The last two papers deal with orthodox Jewish ritual and attempt to trace these obscure ceremonials back into their primitive unconscious origins, parts of which have already been dissected out in the preceding papers. Reik intended this volume to be only the introduction to a much more exhaustive study of all aspects of religion. So far, he has added nothing further to this project, at least publicly; but in his introductory note for this edition he hints that he may take up the theme again.

It is a fascinating mental exercise to follow Reik's thorough, logical reasoning from statement of the details of the ritual to psychoanalytic interpretation. However, it is an exhausting exercise, too, for he employs a heavy, repetitious style which precludes facile reading. Reik is not content simply to make a point—he surrounds it from all angles, so that when he finally closes in there can be no possible doubt that it is inextricably captured. This is probably a relic of the day in which the papers were first written, when psychoanalysis had to be continually on the defensive to protect its scientific position.

This book belongs—at least partly read—in the library of every student of psychoanalysis. It is hard to think it would be of any interest elsewhere. Since Reik draws heavily on Freud's *Totem and Taboo* for reference material, and since Freud wrote a laudatory preface for the German edition (which is included in this translation), it may be assumed that Reik's reasoning and interpretations come with the real endorsement of his teacher.

HELEN HEWITT ARTHUR

DEEP ANALYSIS. *The Clinical Study of an Individual Case.*

By Charles Berg. W. W. Norton and Company, New York. $3.50. 254 pp. 1947.

Without a doubt *Deep Analysis* is one of the most fascinating and provocative new books in the field of psychoanalysis. In it Berg attempts the impossible task of reporting in full an entire psychoanalysis. Even though he does not succeed, because of temporal and spatial limitations, his condensed report on Chris Martin is still the most complete step-by-step description of an actual orthodox psychoanalysis that is available.

The book is divided into three sections. Part I, entitled Father, begins with the initial interview, in which the highly intelligent patient presents his problem vaguely as being a sort of emotional emptiness—he isn't getting out of life the enthusiasm and enjoyment that other people seem to. The reader is then given actual excerpts from succeeding interviews, through which Berg is able to point out how the patient has a deep and unconscious fixation on his father, reflected of course at this stage of the analysis in the patient's immediate positive reaction to the psychoanalyst.

Part II, Mother, is the next stage in the analysis, in which material relating to the patient's even earlier and more deeply repressed attachment to his mother comes out. A variety of psychoanalytic problems are illustrated graphically through these interviews—the problem of anxiety, the problem of money as a psychological issue, the problem of the etiology of accidents, and the most universal problem of all, the resistance to the psychoanalytic process. Through these by-ways of the analysis, Berg includes many of his own interpretive comments to the patient, as well as quoting Chris directly. It is a method whereby both patient and therapist are revealed, and one which few psychiatrists, therefore, have been willing to utilize so generously.

The last section, entitled Son, is Chris's final emergence from his infantile Oedipus fixation into his own role as a capable young man growing out of his childish family ties into a mature life of his own.

Berg has edited his case material intelligently as well as dramatically. The sequence of the patient's changes, his twists and turns as the psychoanalysis develops, is coherent and logical. At the same time, it possesses all the zest of a novel to a reader who has some understanding of psychoanalysis. Throughout the book, the author, as was said, interpolates explanatory passages about what is going on. Even so, it is highly debatable whether the lay reader—the dust jacket's contentions to the contrary—can really follow what the psychoanalysis is all about. To the student of psychiatry and psychoanalysis, however, *Deep Analysis* can be a valuable clinical text, and on that basis the book should be widely read.

HELEN HEWITT ARTHUR

SEX VARIANTS. *A Study of Homosexual Patterns. Second Edition.*

By George W. Henry, With Sections Contributed by Specialists in Particular Fields. Paul B. Hoeber Medical Book Department of Harper & Brothers, New York and London. $8.00. xxiv + 1130 pp.; ill. 1948.

In these days of rocketing book costs, it is a grateful shock to meet an expensive book reissued at a lower price ($4.00 less, to be precise) than in its original format. This has been made possible through a one volume edition containing all the text of the original except a glossary of the language of homosexuality and a slang vocabulary, formerly included in the appendix and certain photographs of physical characteristics suggesting masculinity or femininity. A brief preface

the one-volume edition discusses changes in military, legal, medical, and general public attitudes toward homosexuality. For the review of the original, see Q. R. B. 16: 507. 1941.

HUMAN BIOLOGY

PEOPLE WHO INTERMARRY. *Intermarriage in a New England Industrial Community.*

By Milton L. Barron. Syracuse University Press, Syracuse. $3.00. xii + 389 pp. 1946.

This is a sociological study of intermarriage in the author's home town in Connecticut. He considers the conditions of intermarriage as influenced by race, ethnic grouping, and religion, and finds that racial dissimilarity proves the greatest obstacle to intermarriage whereas ethnic grouping is the least important obstacle. He finds also a general tendency for intermarriage to occur along economic educational cleavages. There is an important and useful introduction to the book, dealing with previous efforts to define terms and methodology, and with a very good historical account of the efforts, both past and present, at the institutional control of intermarriage. This is a rather important book on a rather neglected topic. The author states that only one previous book dealing with this matter has been published.

WENDELL MUNCIE

YOUR MARRIAGE AND FAMILY LIVING. *A text on (1) the history of, changes in, and problems of the American family; and (2) the adaptation of the individual as a child, a mate, and a parent in the family. The American Home and Family Series.*

By Paul H. Landis. Consulting editor: Helen Judy Bond. McGraw-Hill Book Company, New York and London. $2.20. xvi + 373 pp.; ill. 1946.

This is a textbook on the history of changes in the American family and of its problems. It considers the adaptation of the individual within the family, as child, mate, and parent. The book is full of common information, very well presented, and with a number of telling diagrams to bring home especially important points. The information given here ought to be available to everybody who has a family or is interested in having one. Headings of the chapters will indicate the scope: 1) Changes in the American Family; 2) The American Family in Country, Town, and City; 3) Mate Selection in America; 4) Successful Marriage in America; 5) Successful Parenthood in America; 6) The Successful American Family; 7) Crises in The American Family; 8) Planning for Better Families in America. Attention is drawn not only to well-accepted fact but as well to many unsolved problems in this field. The book could very well be recommended for use as a textbook in those high school and college courses stressing family life.

WENDELL MUNCIE

SEX, MARRIAGE AND FAMILY.

By Thurman B. Rice. J. B. Lippincott Company, Philadelphia and New York. $2.50. 272 pp. 1946.

This is a very sensible statement of the issues indicated in the title. Written in wartime, it contains four chapters having to do with relations between young people and marriages occurring in wartime and after, eminently sensible material which might well be taken to heart even in these years of peace.

WENDELL MUNCIE

THE AMERICAN PEOPLE. *A Study in National Character.*

By Geoffrey Gorer. W. W. Norton and Company, New York. $3.00. 246 pp. 1948.

These observations of an intelligent Englishman on typical attitudes of a large number of Americans make worthwhile reading, in so far as they are based on experience. Many of the author's theses are interesting, although neither very new nor very deep (e.g., on the anti-authoritarian and egalitarian attitude of Americans, their loneliness, mobility, the role of women, of the dollar, etc.), nor is the presentation very systematic or comprehensive. The author becomes positively ludicrous when he attempts to "explain" his data psychoanalytically (as in deriving the attitude of Senate and House from an older-younger brother pattern, or the milk consumption of American men from a hypothetical particular preoccupation with women's breasts).

Like all recent writers on "national character," the writer assumes tacitly that there exists in every nation such a thing as a single pattern of stable and nationally universal character traits. While this is understandable in non-scientific writers, one is disappointed to encounter this a priori attitude in people with a scientific training, because such a premise seems by no means scientifically established. It is primarily this preconceived opinion which makes the author present as significant national characteristics those traits, small or big, that are common either to all Anglo-Saxons, or to all modern industrialized nations or to certain classes within such nations, or to all human groups. Neither uniformity in dress, nor receptionists in restaurants, nor disorientation in child upbringing, nor vitamin rackets, nor atomization of knowledge, nor emotional memories of mass killing of pigs, etc., etc., nor, unfortunately, ethnocentrism, are "typical" American traits.

This book has not dispelled the reviewer's doubts of the particular professional qualifications of anthropologists—persons trained in the study of savage tribes and therefore in general unfamiliar with sociology, history, and non-Freudian psychology—to deal with the problem of "national character."

ERWIN H. ACKERKNECHT

THE NEGRO LOOKS INTO THE SOUTH.

By Reverend Edward Gholson. Chapman & Grimes, Boston. $1.25. 115 pp. 1947.

A Negro reverend gives a short and unfortunately correct survey of a situation which he in one place summarizes as "ghettoes for his [the Negro's] living quarters, squalor for his environment, often inferior books for his education, less pay for his teachers, lower wages for his labor, inferior accommodations for his travel, humiliation for his presence, barriers for his higher education, political exclusion for his share in government, higher costs for lower living, and many other furtive but pricking humiliations...." The author is, on the other hand, full of understanding for the problems of the White South, and asks the church to lead towards an unavoidable change in the racial situation.

ERWIN H. ACKERKNECHT

THE WAY OF THE SOUTH: *Toward the Regional Balance of America.*

By Howard W. Odum. The Macmillan Company, New York. $3.00. vi + 350 pp. 1947.

How true it is that the mote in another's eye is so evident, when the beam in our own is seldom noticed! It is so easy for those in the North to see and criticize social and political injustices in the South, not realizing that in their own regions of the United States there are also grave shortcomings. This beautifully written and thought-provoking book by a veteran author and professor at the University of North Carolina shows so clearly how the southern folkways, the social, cultural, and religious patterns of the four main strata of society and the dichotomy within those strata came to be. The author has given us a biography of the South. Although the folkways tend to persist to a remarkable degree, he shows that nevertheless the South is changing, and because of forces within herself. Too often criticism from the outside, particularly by those who do not fully understand the significance of the patterns they see, and who have not been watching long enough to realize that there is substantial growth and progress, throws the South back anew on its old attitudes of defense. Sudden revivifications of the old sectional conflict have occurred, once because of the depression New Deal pressure, a second time because of the pressure of war, and now again as rival candidates eye the ballot box. So, again and again the South expends its energies in protest rather than in developing its powers. Certainly, this book should be very widely read, particularly in the North and the Far West.

ROBERT L. PENDLETON

PRAYER STICK CUTTING IN A FIVE NIGHT NAVAHO CEREMONIAL OF THE MALE BRANCH OF SHOOTINGWAY.

By Father Berard Haile. The University of Chicago Press, Chicago. $3.00 (paper). xvi + 246 + 14 pp. + 9 plates; text ill. 1947.

NAVAHO SACRIFICIAL FIGURINES.

By Father Berard Haile. The University of Chicago Press, Chicago. $2.50 (paper). xviii + 100 pp. ill. 1947.

Prayer Stick Cutting is a minutely detailed presentation of the actions, prayers, and songs in the Navaho ceremony of this name. There is no general discussion. This is a factual presentation of the raw material. The Navaho text for the principal prayers and songs is given. A notable feature is the inclusion of eight plates in full color portraying the prayer sticks.

Navaho Sacrificial Figurines is a small monograph describing those minor rites practised by the Navaho in which animal figurines are used. The author in his Foreword states that these small ceremonies are conducted frequently, but remain unnoticed by the public, both native and foreign, because they are private affairs. The figurines prepared are simple; only a few intimate friends attend. The ceremonies actually seem to be excerpts from the larger chantway ceremonials.

In these two studies there is no attempt at generalization. The value of the studies, aside from their interest to students of Navaho ceremonies, lies in the included raw material for comparative studies and the incidental inclusion of much material of interest to people working in allied disciplines. For example, in *Navaho Sacrificial Figurines* there is repeated mention of the use of sweet corn in these ceremonials. This is a point of considerable interest to students of plant origins, as the occurrence of specific plants in ceremonies is often evidence of their antiquity. Sociologists and psychologists interested in primitive thought patterns would, of course, find a wealth of material in such studies.

GEORGE F. CARTER

HAWAIIAN AMERICANS. *An Account of the Mingling of Japanese, Chinese, Polynesian, and American Cultures.*

By Edwin G. Burrows. Yale University Press, New Haven; Geoffrey Cumberlege, Oxford University Press, London. $3.00. iv + 228 pp. 1947.

The war record of the 442nd Regimental Combat Team (Hawaiian Nisei), "probably the most decorated unit in the United States military history," and other symptoms of successful acculturation of "orientals" in Hawaii have provoked this attempt to survey the numerous anthropological detailed studies on the assimilation of Polynesians, Chinese, and Japanese in Hawaii. To the author the problem is one of "haole [white] prestige." This prestige was impressed upon the Polynesians mostly by armed force, upon the "orientals" by education and the whole economic set-up. The author describes faithfully how the second generation learns to despise its parents, and to acquire such essentials of North American civilization as ball games and "romantic" love; how Japanese Buddhism itself becomes Americanized, and so on. He shows that the standard answer to white domination in Hawaii has been cooperation, that aggression was always extremely rare, and that even "withdrawal" reactions (alcoholism, new cults, especially healing cults; "recreative reversion," etc.) were rather limited in scope. That this is a very rare occurrence in colonial history is well known. Why it has happened in Hawaii remains essentially unexplained by so short and superficial a book.

ERWIN H. ACKERKNECHT

VIRGIN ISLANDS. *In Story and Pictures. Pictured Geography, Fourth Series.*

By Marguerite Henry; pictures by Kurt Wiese. Albert Whitman and Company, Chicago. 75 cents. 28 pp.; ill. 1946.

A brief account of the historical, economic, and geographical features of the Virgin Islands. The illustrations are not particularly attractive to the reviewer, but the text should serve to introduce children to this little-known possession of the United States.

THE SOUTHERN AMERICAS. *A New Chronicle.*

By Abel Plenn. Creative Age Press, New York. $4.00. xiv + 455 pp. 1948.

There is indeed great need for a better understanding of the Southern Americas and of the Caribbean—to understand how and why the social, commercial and land use patterns have developed as they have, and to understand the enormity of the curse which the Iberians laid upon their colonies from the beginning. It is also important that we in the United States appreciate at least something of the malevolent influences and pressures which have been and continue to be brought to bear from time to time upon many of the countries to the south of us; and to realize that unless we are very careful, our continued support of certain regimes will so strengthen reactionary forces that communism will continue to seem the only way out for all but the wealthy few who continue to try to hold the lid down.

Particularly for tourists in California, the times and leaders of the Conquest of the western hemisphere have been glamorized. There were indeed noble characters among the clergy, both those who came in the vanguard, and those who followed through the centuries. However, the leaders of the Conquest were of different stuff. They were all too human, as is so clearly brought out in the more than 125 selections here, taken frequently from contemporary writings, and in some cases from the very pens of leaders in the events. A clearer indication of the dates of the original sources would add to the interest. These quotations make up about half the book. The author has endeavored to give unity to the chronicle with an introductory and interpretative section preceding each quotation. However, there is too much of this: these sections seem labored. At times the endeavor to achieve a poetic style, by means of excessive repetition, reminds one of an oratorio.

ROBERT L. PENDLETON

PRIMITIVE SOCIETY.

By Robert H. Lowie. Liveright Publishing Corporation, New York. $2.49. xiv + 463 pp. [1920]; 1947.

A reprint edition, with a new preface by the author, of what has become since its first publication nearly thirty years ago a standard work in its field. The publishers are to be commended for making it available in this moderately priced and attractive edition.

TRIBES OF THE LIBERIAN HINTERLAND. *Report of the Peabody Museum Expedition to Liberia. Papers of the Peabody Museum of American Archaeology and Ethnology, Harvard University, Volume XXXI.*

By George Schwab; edited, with additional material by George W. Harley. Peabody Museum of American Archaeology and Ethnology, Harvard University, Cambridge. $10.00 (cloth); $7.50 (paper). xx + 526 pp. + 81 plates + 1 map; text ill. 1947.

The author and his collaborator both are "old-timers" in West Africa and have had extensive experience with the natives. Their scholarly collection of ethnological observations on the inland tribes of Liberia forms a valuable contribution to anthropological literature, in which this area has been so far very much neglected. This volume contains a wealth of new, sound information on the cultural, social, and spiritual life of the various tribes considered, but it does not attempt to make systematic comparisons or draw any general con-

clusions. The volume starts with a description of the Liberian hinterland and its human inhabitants, especially their traditions. The main topics, discussed in detail, are the following: the villages, agriculture, domestic animals, methods of fishing, trapping and hunting, food, dress, handicrafts, weapons, music, social organization, sex relations, child training, war, burial customs, religious concepts and cults, medical practices, laws, and proverbs. A final, brief summary on "native character traits" is of particular interest to biologists. Here it is stated, e.g., that "primitive Negroes are less sensitive to pain than white people," "their olfactory and taste systems do not react like ours" (decaying flesh and fish is eaten with relish and with impunity), "sight and hearing are no better than in the white race," but "the outstanding exception is the native's ability to see in blinding sunlight." "Most of the people are never far from actual hunger" and their diet as a whole "is sadly deficient in protein." Many diseases are rampant: "all natives have latent malaria all their lives," "hookworm is very common; perhaps fifty percent of the population harbor these parasites," "yaws affects even more of the natives," "gonorrhea is common, and schistosomiasis is a serious problem in the interior as is also trypanosomiasis." Perhaps worst of all is the natives' strong tendency to suppress and, if possible, to eliminate by one means or another any individuals "who stand out above the common level" and thus to discourage completely any initiative and all progress in their society.

The appendix contains a detailed glossary of native terms and notes on the native languages. The many plates of photographs are, unfortunately, quite poorly reproduced.

A. H. SCHULTZ

LAND AND POVERTY IN THE MIDDLE EAST. *Middle East Economics and Social Studies.*

By Doreen Warriner. Royal Institute of International Affairs, London and New York. $2.50 (paper). viii + 149 pp.; ill. 1948.

This is a small book discussing a very difficult and important subject, because near starvation, pestilence, high death rates, soil erosion, and economic exploitation make up the pattern of life for the masses of the rural population in the Middle East. It is a poverty which has no parallel in Europe. Money incomes are very low, but money comparisons alone do not convey an idea of the filth and disease, and the mud huts shared with animals. As a result of the Jew-Arab controversy and the impact of power politics in this region, the peoples of the Middle East have become self-conscious. This part of the world is in a state of turmoil; it is no longer bound by tradition. Although political and national controversies again dominate the scene, there is no organization which can put the economic progress of the Middle East or the security of the peasant population in the foreground.

The first essential is not to put more people on the land, but to raise the living standard of the population already there. All those influences which make for poverty, indebtedness, ignorance, and instability are reinforced by the social structure, particularly by the systems of land tenure, and unless this is changed there can be no real advance. Some of the conditions are best illustrated by comparing conditions in different countries. Egypt has a rural population density of 1,450 per square mile of cultivated land, ten times as high as the average density of rural population in Europe. In the last half century the population has increased faster than the increase of cropped area. The standard of living is low—the consumption of even energy-producing foods is very low. The conditions of the peasant's life are of unrelieved horror—almost a slave population. The distribution of land ownership is extremely unequal. The social system is described as feudal, but it has in fact none of the merits of feudalism, for there is no element of responsibility on the part of the landowner class. The Egyptian "pashas" are cotton lords, big business men controlling large fortunes, who hold the entire country in their grip and are utterly opposed to any measure which would raise the level of the cultivators. Although the government is in complete control of production, it will never use its powers to modify the powers of the landlords. Land reform must therefore wait upon political change, and may one day become the main motive for revolution.

In view of the aura of vast possibilities which propaganda has created around the agriculture of Palestine, it is important to remember (1) that it is a small country, and (2) that its soil is shallow and infertile. With the present amount of land, a large part of the Arab population must necessarily live on a very low level. However, there is no doubt that the standard of living of the Arab rural population there has risen during the period of mandatory rule. Palestine, by comparison with the other Middle East countries, does not suffer from the evils of absentee landlordism on a large scale. It is in the Jewish communal settlements that the most striking technical and social changes have been carried through; but from an economic standpoint they are not really a model, since they depend on the investment of very large capital resources, far beyond what can ever be made available to the Arab community. So far as grain farming is concerned, there can be no doubt that the return from farming does not cover costs.

In Iraq, by contrast, there are very disturbing trends. The sheikhs or city notables install irrigation pumps, supply them to the peasants at extortionate rates of interest, and so gradually acquire the land in payment of debt. Thus in the regions of pump irrigation the tribal system of land ownership has entirely ceased to

function. The land is mainly the property of the pump owners. During the period of the mandate some of these trends were accentuated. This wholesale alienation of the land in large blocks causes great injustice to the cultivators and also creates great obstacles to future development.

Because extreme poverty is general, and is everywhere the result of the low productivity of the land and of the excessive share of the farm income taken by the landlords, there is great need for new forms of land tenure. There is also great need for agricultural planning for the whole Middle East, planning which will cover the entire range of economic development.

ROBERT L. PENDLETON

THE EARTH'S FACE AND HUMAN DESTINY.

By Ehrenfried Pfeiffer. Rodale Press, Emmaus, Pennsylvania. $2.75. 184 pp. + 1 plate; text ill. 1947.

As the title might suggest, the anthropomorphic point of view appears repeatedly in this small book, which contains a very curious mixture of observations, opinions, and practical suggestions for soil conservation. Strange analogies are drawn between animal organisms and the landscape. In the chapter on basic biological principles we are told that the laws relating to liquids hold good for the liquid contents of plants. And since the earth is a living organism, these laws must be valid in every part of it: "The metaphor of an organism." The theme of the book is stated to be that for the shaping of new environments, man must look to more than economics and must accept from art, science, and philosophy formative ideas. The adults of the present generation will not share in our own advanced way of thinking, will not "profit," since development of a landscape requires centuries—but spiritually that is all the more reason to redouble our efforts. The maintenance of the landscape is a cultural activity.

As would be expected in a book published in Emmaus, we find extreme statements such as that of the significance of "earthworms, without which there would scarcely be any agricultural soil," and again: "The production of a neutral humus compost or a ripe humus manure is the alpha and omega of soil culture." And we are told to use such cultural practices as will avoid the formation of a podsol! We are told further that the plow, the draft animal, and milk, important elements in present day agriculture, were first used in religious ceremonies alone and only later were converted into utilitarian purposes.

The author urges the reader to study the illustrations and their captions. Certainly the latter could, with profit, be much fuller and more explicit.

ROBERT L. PENDLETON

FARMERS OF FORTY CENTURIES *or Permanent Agriculture in China, Korea and Japan.*

By F. H. King; edited by J. P. Bruce. [Organic Gardening Press] Rodale Press, Emmaus, Pennsylvania. $5.00. 379 pp.; ill. [No date.]

It is indeed a pleasure to see again in print this classic description of the agriculture of some of the best and most productive portions of China, Japan, and Korea. It was about 1906 that F. H. King spent hardly six months studying at first hand the methods and products of agriculture and truck gardening in Asia. He was indeed a most unusual and competent observer—for it is still amazing how much he recorded in notebook and by camera, and how shrewd many of his deductions were. He was much impressed with the fact that the farmers had, through empirical methods, come to use often very effective methods for conserving soil fertility, and knew how to get the utmost out of the limited areas of agricultural lands in those parts of Asia. He did not appreciate, however, that in some cases the farmers of China lose important quantities of nitrogen, for example, by following faulty empirical methods. The occidental reader cannot read this book without realizing why it is that tractors and other agricultural machinery cannot be generally used in those countries. This is indeed an essential book for all interested in the agriculture of eastern Asia.

The present edition has been well edited, without losing the flavor of the original. The text has been only slightly condensed; a careful comparison with the original edition shows that no agriculturally significant changes have been noted. The longest single deletion is of two pages, in the course of which King regrets that "the western tobacco habit, selfish beyond excuse, filthy beyond measure" had been spreading extensively in China! Portions of several pages discussing Oriental racial characteristics, and some paragraphs expressing surprise at the relative absence of flies, have also been omitted from the new edition. The number of halftones has been reduced from 248 to 209; in many cases their quality in this edition is even better than in the original.

ROBERT L. PENDLETON

AIDS TO GEOGRAPHICAL RESEARCH. *Bibliographies, Periodicals, Atlases, Gazetteers and Other Reference Books. American Geographical Society Research Series Number 22. Second Edition.*

By John Kirtland Wright and the late Elizabeth T. Platt. Columbia University Press, New York. $4.50. xii + 331 pp. 1947.

As the authors say, the main part of the volume consists of selective lists of bibliographies, periodicals, atlases, and other reference works; and its purpose is not to furnish the student with references to the pri-

mary works on which to base his investigations, for no single book could do this adequately for the whole immense subject of geography. The lengthy introduction, which discusses not only the nature of geographical studies, but also the aids to geographical research, is well worthy of study by other scientists as well as geographers.

ROBERT L. PENDLETON

RURAL LIFE IN ARGENTINA.

By Carl C. Taylor. Louisiana State University Press, Baton Rouge. $6.00. xxii + 464 pp.; ill. 1948.

This excellent book starts with a short, but lively, description of the author's travels through the main agricultural regions in Argentina: The cattle-breeding and the cattle-feeding belt; the corn belt; the wheat belt; the Yerba-mate belt and the cotton belt; the sugar cane, the vineyard, and the sheep belt. A systematic analysis of these regions is given in later chapters.

Population is analysed according to national origins (Spaniards and their descendants are only a minority), age, sex, etc. A historical survey of agriculture and settling shows that modern developments started only in the 1870's. In this process agriculture diversified tremendously, but remained the backbone of Argentine economy (in spite of her overgrown cities). Big land ownership still prevails in spite of the new farmer and tenant classes to which the author devotes particular attention. Argentine agriculture is highly mechanized, but transportation is still largely dependent on water courses. The farmer is often very isolated, a fact which might partly account for the high rate of illiteracy, illegitimate unions and births, and the political set-up. Compared to other South American republics material standards of living of the masses (food, health, etc.) are relatively high. There might be some causal connection with an equally relatively low birth rate. Cultural standards (education, etc.) are low. Dr. Taylor discusses also agrarian reform movements and organization.

This is a well documented, intelligent, unprejudiced, and very interesting study, one of the four or five books on Argentina in English worth reading.

ERWIN H. ACKERKNECHT

THE WAYS OF MEN. *An Introduction to Anthropology. The Century Social Science Series.*

By John Gillin. D. Appleton-Century Company, New York and London. $4.50. xviii + 649 pp. + 32 plates; text ill. 1948.

This textbook of anthropology starts with a short historical sketch that is unfortunately not free from factual errors. The first quarter of the book gives a competent survey of physical anthropology, dealing with the primates, fossil man, living races, and race mixture. Although the author takes particular pains to coordinate physical and cultural anthropology, he is not more successful than all those who made a similar attempt previously, and the wisdom of uniting both disciplines in one book might therefore be doubted.

The rest of the book is devoted to cultural anthropology. The notion of culture; its learned character, and the mechanisms of learning; its dealing with basic and acquired drives; culture patterns and integration; culture contact and culture change are discussed extensively. Types of social organization are reviewed. Probably the best chapters are those surveying the development of technology. There are rather meager chapters on symbolism and personality formation.

The book is well written and courageous. That it is so strangely abstract in some parts and relatively unsubstantial is no individual fault of the author. It is simply the consequence of his following certain contemporary trends in American anthropology. Since Linton's *Science of Man* many American anthropologists have attempted to live up to the accidental title of their profession instead of realizing that actually they are trained ethnologists, most of them able to contribute only certain stones in the building of the "science of man." The result is that they have lost contact with their own subject matter, and have, with not always very critical borrowings from neighbouring disciplines like sociology and psychology, created a theoretical system where truisms are often expressed in a highly complicated terminology. This step was perhaps unavoidable. One would feel less critical about it, were it not so often combined with an ill-founded feeling of achievement and superiority, e.g. toward the work of the late Franz Boas and his pupils who neither were, nor claimed to be, perfect but gave American anthropology internationally an unequalled position. One of the least lovable traits of this new school in American "anthropology" is its chauvinism. To single out, for instance, France as a center of prostitution (p. 495) as our author does, was entirely gratuitous, as he might meanwhile have learned from the Kinsey report.

Those who want to teach anthropology along the theoretical lines, characterized above, will find in Professor Gillin's book a well rounded and competent textbook, based on an extensive knowledge of the literature and provided with all the necessary apparatus (bibliographies, etc.).

ERWIN H. ACKERKNECHT

BIOMETRY

INDUSTRIAL EXPERIMENTATION.

By K. A. Brownlee. Chemical Publishing Company, Brooklyn. $3.75. 151 pp.; ill. 1947.

Despite its title, this is a book on statistics. It is, however, designed primarily for those who are concerned with pilot-plant and plant-scale experiments on chemical manufacturing processes. The illustrations and problems are selected almost entirely from the chemical industry.

The author's emphasis is on the analysis of variance as a statistical tool. Rectilinear, curvilinear, partial, and multiple correlation, for example, are all treated as variance problems. Considerable stress has also been placed on experimental design as an integral part of statistical analysis.

On the whole, one cannot help but be impressed by the amount of solid statistical material the author has crammed into this small book. It is especially noteworthy that the author makes explicit many assumptions about the analysis of variance which are often ignored in longer texts on this subject. As an illustration, this is the first text the reviewer has seen which states explicitly that a Latin Square type of experimental design is valid only if there are no interactions between factors.

This is not an easy book to read, but it is highly recommended to statisticians and scientists with some background in statistics, whatever their fields of specialization.

A. CHAPANIS

DE OMNIBUS REBUS ET QUIBUSDEM ALIIS

THE GREAT HERITAGE.

By Katherine B. Shippen; illustrated by C. B. Falls. The Viking Press, New York. $3.50. x + 230 pp. + 1 map; ill. 1947.

Our American heritage of furs, trees, fish, gold, oil, coal, water power, and land for wheat, corn, cotton, and tobacco, is here brought alive by inspired writing that drives home both the adventure and thrill of rapid accomplishment, and a horror of the senseless waste that accompanies it. Without proselytizing, Katherine Shippen makes conservation urgent, and shows how widely the need of it applies. To achieve this blend she has vividly retold some of the sagas of Paul Bunyan and Joe Magarac, of Johnny Appleseed and John Jacob Astor. In tracing the swift mechanization that freed hands and minds for fresh developments, there is a long and laudatory account of the Tennessee Valley Authority. No inference is drawn on the vast increase of other federal activities. The book is concerned with presenting a picture of the heritage, rather than with reporting in detail our treatment of it.

In such a condensation of three overflowing centuries, it is almost inevitable that many major factors must go unmentioned. The usual humanitarian bias is followed in discussing the achievement of Lincoln in freeing the slaves, so that there is no indication of the slaves being more than forced labor. Yet they cost their owners money, and represented a large part of southern capital—liquidated without compensation. The mouths remained to be fed, just as the land remained to be worked. But the former slave-owners had insufficient capital left both to reconvert to the new order and also to pay the costs of their military defeat. In such an excellent and enthusiastic account of American history as this book, it seems a pity not to have made this point clear. Southerners have considerable justification for resenting its continued neglect when criticism is leveled at their present backward state.

LORUS J. & MARGERY J. MILNE

WAY OF THE WILDERNESS. *A Complete Camping Manual; A How to Do It Camping Guide.*

By Calvin Rutstrum. Burgess Publishing Company, Minneapolis. $2.50 (paper). viii + 192 pp.; ill. 1946.

A camping guide, sturdily bound and in a protecting cloth case. The subject material is that usually found in such guides, but is presented in clear-cut, simple manner that makes it very readable. Many illustrations aid the explanations in the text, and the book includes pertinent remarks on recent developments in dehydrated foods and insecticides. While avoiding elaborate presentations, the author has succeeded in making a worthwhile guide that should be of interest to campers, particularly in the novice class for which it is intended.

JOHN E. CUSHING

CACHE LAKE COUNTRY: *Life in the North Woods. By John J. Rowlands; illustrated by Henry B. Kane. W. W. Norton & Company, New York.* $3.50. 272 pp.; ill. 1947.

Up somewhere in the North Woods is a small lake, known only to a few white men, far enough away to be safe from the encroachment of civilization. There in the primeval wilderness the authors built cabins and enjoyed the life that most of us live only vicariously. Month by month the reader is shown the daily activities of the two men and their Indian friend, how the forces of nature are combatted by those wise in the ways of northern winters, how the spring is prepared for and enjoyed when it finally arrives, the exploration trips in the summer, and the preparations for winter in the fall. In all these pursuits there is complete cognizance of nature, flowers and animals alike, for in the wilderness every organism has a purpose, whether merely as a harbinger of a season or as an emergency food. The reader is told all these facts, and so the book is replete

with wilderness lore. Valuable directions are given for taking care of one's self when deprived of the conveniences of a civilized existence. These include recipes, methods of constructing canoes or candle holders, and a thousand and one useful hints and cautions to be observed in order to insure a safe and pleasant life in the wilderness. Pen-and-ink drawings fill the leaf margins and depict the instructions and descriptions in the text. Sometimes the drawings are full page and illustrate the construction of hunting sleds, moccasins, ice boats, outdoor ovens, etc., or merely the beauty of the country and its animals and plants. Some of these sketches are in a highly humorous vein. Anyone who desires to lose himself away from home can do no better, other than by actual travelling, than to read this narrative.

HENRI C. SEIBERT

LAND FOR THE FAMILY: *A Guide to Country Living. By A. F. Gustafson, E. V. Hardenburg, E. Y. Smith, and Jeanette B. McCay. Comstock Publishing Company, Ithaca, New York.* $4.00. xxiv + 501 pp.; ill. 1947.

Land for the Family constitutes a complete and practical guide to country living, written by experts. It should be of special value to people of moderate means who contemplate living in the country, or to those already there who wish to become partially self-supporting. The book deals with a wide range of topics, among which may be mentioned the selection of a community, the choice of a house and land, soils, fertilizers, and methods of cultivation, vegetable and flower gardens, landscaping, crops and fruit growing. Essential data regarding various phases of animal husbandry are included, together with information about wild life conservation and woodlands and their use. A section devoted to nutritional needs includes chapters on the kitchen, food, canning, freezing, methods of preserving, and fruit juices. Each chapter is supplied with a list of suggested readings and an adequate index is appended. The book is illustrated by over 200 photographs and drawings.

ALBERT F. HILL

STEDMAN'S PRACTICAL MEDICAL DICTIONARY. *Sixteenth Revised Edition.*

Edited by Norman Burke Taylor in collaboration with Allen Elsworth Taylor. A William Wood Book, The Williams & Wilkins Company, Baltimore. $7.50 (with thumb index); $7.00 (without thumb index). xxxviii + 1291 pp. + 23 plates; text ill. 1946.

This sixteenth edition of a well known work, revised, enlarged and brought up to date, is certain to prove extremely useful not only to the medical profession but to all those concerned with the biological sciences. The derivation and pronunciation of each term is given. Diseases, signs, tests, etc. are given under their specific names rather than under general categories, e.g., Gairdner's disease is under Gairdner not disease, Fehling's solution is under Fehling. Separate tables summarize and compare much useful information, e.g., weights and measures in different systems, the BNA and other nomenclatures. The book is graced by a separate and unusually complete and informative medical etymology giving both Greek and Latin roots in common medical use.

Future editions should include the commoner statistical terms. Neither mean nor mode is given, much less standard deviation or chi square. The genetics and cytology should be renovated. Genetics is defined as "the science which deals with natural development, as distinguished from eugenics, or the science of development through artificial selection." Mendel's laws are limited to plants. The haploid number of human chromosomes is given as sixteen! Mitosis is still called "indirect" cell division, while "gametogenetic mitosis" is defined as "the process of cell-division characteristic of the ovum after union with the spermatozoon, in which the number of chromosomes in each of the conjugating cells is reduced by one-half. . . ." Biophysical and biochemical terms fare better, although the newer meanings of oscillograph and cytochrome should have been included. These are of course but details in an otherwise magnificent volume of over 1,290 pages.

GAIRDNER MOMENT

THE ELECTRON MICROSCOPE. *Sigma Introduction to Science 8.*

By V. E. Cosslett. Sigma Books, London. 7s. 6d. viii + 128 pp. + 12 plates; text ill. 1947.

An excellent introduction to the principles of electron microscopy, written in non-technical language that very clearly pictures the points discussed. The author first considers the general problems relative to light microscopes and from this base leads into a discussion of electrons, electron lenses, and the various methods that have been devised to make electron microscopes. The industrial, biological, and other uses of the microscope are discussed, and present problems and future possibilities considered. Many excellent illustrations accompany the text and help to make it highly desirable for the teacher or student who would like to know more of this instrument.

JOHN E. CUSHING

ANNUAL REPORT OF THE BOARD OF REGENTS OF THE SMITHSONIAN INSTITUTION *showing the operations*

expenditures, and condition of the Institution for the year ended June 30, 1946. Publication 3871.

Smithsonian Institution, Washington, D. C. $2.25. x + 440 pp. + 52 plates + 1 map; text ill. 1947.

In addition to the Annual Report, this volume contains the customary excellent selection of non-technical papers from a wide variety of scientific fields. The biological papers are the following: The Natural History of Whalebone Whales (N. A. Mackintosh); Life History of the Quetzal (A. F. Skutch); The Sun and the Harvest of the Sea (W. L. Schmitt); Anthropology and the Melting Pot (T. D. Stewart); Archeology of the Philippine Islands (O. R. T. Janse); The March of Medicine (M. M. Wintrobe); Technology and Medicine (K. S. Lion). In addition, general articles on the national responsibility for research and the progress of science, and special articles in other fields, such as Harlow Shapley's article on The Astronomical Dating of the Earth's Crust, and Arthur H. Compton's on Atomic Energy as a Human Asset, cannot fail to interest every scientist. It cannot be too often repeated that these collections of general papers are too good to be ignored by any scientist and particularly those who teach a science; and that similar collections published elsewhere usually cost three or four times as much.

BENTLEY GLASS

SCIENCE AND LIFE IN THE WORLD. *Volume I. Science and Civilization; The Future of Atomic Energy. Volume II. Transportation—A Measurement of Civilization; Light, Life, and Man. Volume III. A Challenge to the World. The George Westinghouse Centennial Forum May 16, 17, and 18, 1946, sponsored by The Westinghouse Educational Foundation, Pittsburgh, Pennsylvania. By various authors. Whittlesey House, McGraw-Hill Book Company, New York and London.* $7.50 per set of three volumes, boxed; $2.50 each volume. (I) x + 152 pp. + 4 plates; text ill. (II) x + 236 pp. + 1 plate; text ill. (III) x + 198 pp. + 17 plates; text ill. 1946.

The Geo. Westinghouse Centennial Forum brought together many notable scientists and educators for a series of symposia on Science and Civilization, The Future of Atomic Energy, Transportation, and Light, Life and Man. These published addresses occupy the two volumes of the set, while the third is filled with a variety of miscellaneous addresses (e.g., The Microscope, by Peter Gray), a radio broadcast (Science: Salvation or Destroyer of Mankind), and a biographical study of George Westinghouse. The latter is as interesting as anything in the three volumes. On the whole, as one might expect from a collection of published addresses to a mixed audience, the ratio of verbiage to ideas is very high.

The biological contributions to the Forum included: The Future of Atomic Energy from the Viewpoint of Biology and Medicine (W. Edward Chamberlain); Peacetime Implications of Biological Warfare (Geo. W. Merck); Light and Life—Photosynthesis (C. B. vanNiel); High-frequency Radiation and the Gene (Geo. W. Beadle); The Microbe, Friend and Enemy of Man (Selman A. Waksman); and Molecular Architecture and Biological Reactions (Linus Pauling). This symposium set a high standard, although well-informed biologists will not find in these semi-popular addresses much that they have not already read elsewhere. An exception is the address by George Merck, which still remains the sole officially released report on the preparations for and potentialities of biological warfare. He said little of a specific nature, but that little is highly illuminating—perhaps one should say that the official secrecy surrounding this subject, to an extent surpassing even that about atomic fission, is most indicative.

The addresses on Scientific Ethics (A. V. Hill), The Social Composition of Scientific Power (Isaiah Bowman), and Planning in Science (Vannevar Bush) will also interest biologists, as much for the vast difference in the three points of view as for any other reason. The spokesmen of science are by no means unanimous as to the right and proper relation of science to civilized society.

BENTLEY GLASS

SALMON FISHING ON PUGET SOUND. *How, When and Where to Troll for Salmon, Spinning, Mooching. Salmon Fishing Contribution From the Practical Side. By Harry W. Howard. Binfords & Mort, Portland, Oregon.* $2.50. viii + 127 pp. + 7 plates; text ill. 1947.

The information on tackle, its care and specifications, which this book supplies, should be detailed enough for any addict. Also included, as contributed chapters by other hands, are the salmon fishing laws of the State of Washington, a routine summary of the biological characteristics of the five species of Oncorhynchus, and a short note on the clams of Washington. There are also instructions on how to read a barometer and eight forms in the back to be filled out with records of fishing trips.

J. W. HEDGPETH